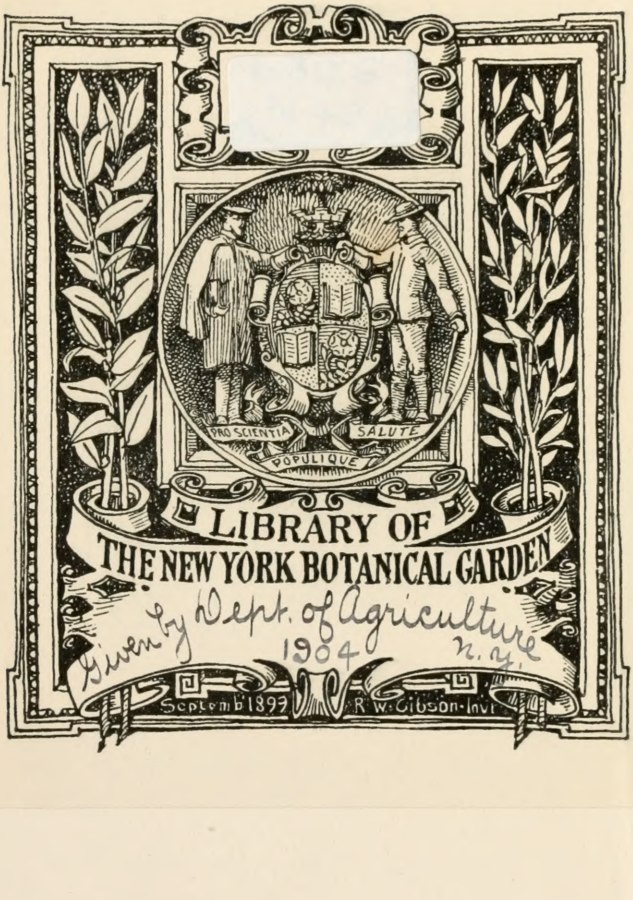
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Nineteenth Annual Report

of the

BOARD OF CONTROL

of the

NEW YORK
Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY),

For the Year 1900,

With Reports of Director and Other Officers.

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TRANSMITTED TO THE LEGISLATURE JANUARY 9, 1901.

ALBANY:
JAMES B. LYON, STATE PRINTER.
1901.

STATE OF NEW YORK.

No. 69.

IN ASSEMBLY,

JANUARY 9, 1901.

NINETEENTH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 9, 1901.

To the Assembly of the State of New York:

I have the honor to herewith submit the Nineteenth Annual Report of the Director and Board of Managers of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CHARLES A. WIETING,

Commissioner of Agriculture.

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ORGANIZATION OF THE STATION.

BOARD OF CONTROL.

GOVERNOR THEODORE ROOSEVELT, Albany.
STEPHEN H. HAMMOND, Geneva.
AUSTIN C. CHASE, Syracuse.
FRANK O. CHAMBERLAIN, Canandaigua.
FREDERICK C. SCHRAUB, Lowville.
NICHOLAS HALLOCK, Queens.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
OSCAR H. HALE, North Stockholm.
MARTIN L. ALLEN, Fayette.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND,
MARTIN L. ALLEN,
FRANK O. CHAMBERLAIN,
FREDERICK C. SCHRAUB,
LYMAN P. HAVILAND,
NICHOLAS HALLOCK.

STATION STAFF.

WHITMAN H. JORDAN, SC. D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*
WILLIAM P. WHEELER, *First Assistant (Animal Industry).*
FRED C. STEWART, M. S., *Botanist.*
LUCIUS L. VAN SLYKE, PH. D., *Chemist.*
CHRISTIAN G. JENTER, PH. C.,
*WILLIAM H. ANDREWS, B. S.,
J. ARTHUR LE CLERC, B. S.,
¶AMASA D. COOK, PH. C.,
FREDERICK D. FULLER, B. S.,
¶EDWIN B. HART, B. S.,
*CHARLES W. MUDGE, B. S.,
*ANDREW J. PATTEN, B. S., *Assistant Chemists.*
HARRY A. HARDING, M. S., *Dairy Bacteriologist.*
LORE A. ROGERS, B. S., *Assistant Bacteriologist.*
GEORGE A. SMITH, *Dairy Expert.*
FRANK H. HALL, B. S., *Editor and Librarian.*
VICTOR H. LOWE, M. S.,
†F. ATWOOD SIRRINE, M. S., *Entomologists.*
PERCIVAL J. PARROTT, A. M. *Assistant Entomologist.*
SPENCER A. BEACH, M. S., *Horticulturist.*
HEINRICH HASSELBRING, B. S. A., *Assistant Horticulturist.*
FRANK E. NEWTON,
JENNIE TERWILLIGER, *Clerks and Stenographers.*
ADIN H. HORTON, *Computer.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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* Connected with Fertilizer Control.
† At Second Judicial Department Branch Station, Jamaica, N. Y.
¶ Absent on leave.

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TABLE OF CONTENTS.

APR 28 1904

NINETEENTH ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *October* 1, 1900.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1900.

APPROPRIATION 1898–99.

MAINTENANCE.

Receipts.

1899.			
Oct.	1.	To balance on hand	$10,839 77
		To custom-house duty returned	20 63
			$10,860 40

Expenditures.

By building and repairs	$1,069 59
By chemical supplies	142 97
By contingent expenses	285 85
By feeding stuffs	128 50
By fertilizers	43 60
By freight and express	88 65
By furniture and fixtures	175 69

By heat, light and water	$299 74
By labor	3,106 98
By library	162 66
By postage and stationery	63 06
By publications	390 60
By salaries	3,778 67
By scientific apparatus	14 55
By seeds, plants and sundry supplies	496 80
By tools, implements and machinery	96 48
By traveling expenses	516 01
	$10,860 40

APPROPRIATION 1899-1900.

SALARIES.

Receipts.

1899-1900.	
To amount received from Comptroller	$17,250 00
To amount due from Comptroller	5,750 00
	$23,000 00

Expenditures.

1900.	
Oct. 1. By salaries	$17,351 34
Balance	5,648 66
	$23,000 00

LABOR.

Receipts.

1899-1900.	
To amount received from Comptroller	$9,000 00
To amount due from Comptroller	3,000 00
	$12,000 00

Expenditures.

1900.			
Oct.	1.	By labor	$9,024 29
		Balance	2,975 71
			$12,000 00

EXPENSES.

Receipts.

1899–1900.			
		To amount received from Comptroller	$11,250 00
		To amount due from Comptroller	3,750 00
			$15,000 00
		By building and repairs	$1,725 18
		By chemical supplies	235 10
		By contingent expenses	1,653 52
		By feeding stuffs	859 49
		By fertilizers	4 72
		By freight and express	174 44
		By furniture and fixtures	495 51
		By heat, light and water	1,516 94
		By library	651 53
		By live stock	582 00
		By postage and stationery	834 45
		By publications	1,213 94
		By scientific apparatus	48 89
		By seeds, plants and sundry supplies	1,123 11
		By tools, implements and machinery	460 40
		By traveling expenses	678 52
			$12,257 74
1900.			
Oct.	1.	Balance	2,742 26
			$15,000 00

EXPENSE OF BULLETINS AND ENFORCING PROVISIONS OF CHAPTER 955, LAWS 1896. APPROPRIATION 1898–1899.

Receipts.

1899.			
Oct.	1.	To balance	$1,320 31
		To amount received from Comptroller	5,000 00
			$6,320 31

Expenditures.

		By heat, light and water	$429 70
		By postage and stationery	36 50
		By publications	3,518 75
		By salaries	2,274 40
		By traveling expenses	54 76
1900.			
Oct.	1.	Balance on hand	6 20
			$6,320 31

COMMERCIAL FERTILIZERS.

Receipts.

1900.		
	To amount received from Comptroller	$2,000 00
	To amount due from Comptroller	2,000 00
		$4,000 00

Expenditures.

By chemical supplies	$191 68
By contingent expenses	1 81
By freight and express	78 94
By heat, light and water	123 49
By postage and stationery	4 06
By salaries	2,580 70

	By seeds, plants and sundry supplies....	$1 38
	By traveling expenses	468 26
	By tools, implements and machinery....	20
		$3,450 52
1900.		
Oct.	1. Balance	549 48
		$4,000 00

Feeding Stuff Law, Chapter 510, Laws 1899.

Receipts.

1900.		
	To amount received from Comptroller..	$500 00
	To amount due from Comptroller......	500 00
		$1,000 00

Expenditures.

	By freight and express	$6 74
	By postage and stationery...........	1 48
	By salaries	587 53
	By seeds, plants and sundry supplies....	6 12
	By tools, implements and machinery....	10
	By traveling expenses	68 59
		$670 56
1900.		
Oct.	1. Balance	329 44
		$1,000 00

Second Judicial District, Chapter 675, Laws of 1894.

Receipts.

1899.		
Oct.	1. To balance	$46 34
1899-1900.		
	To amount received from Comptroller..	7,722 93
		$7,769 27

Expenditures.

	By chemical supplies	$162 77
	By contingent expenses	91 88
	By feeding stuffs	26 50
	By fertilizers	194 60
	By freight and express	81 13
	By furniture and fixtures	12 50
	By heat, light and water	28 92
	By labor	589 82
	By library	3 60
	By postage and stationery	60 67
	By publications	412 80
	By salaries	3,594 76
	By scientific apparatus	20 65
	By seeds, plants and sundry supplies	457 73
	By tools, implements and machinery	140 10
	By traveling expenses	730 96
	By rents (land)	1,159 88
1900.		
Oct. 1.	Balance in Albany $1,975.58 and the appropriation of $8,000 for 1900-1901	$7,769 27

SPECIAL APPROPRIATION, BUILDING AND REPAIRS, APPROPRIATION 1898-1899.

Receipts.

	To amount received from Comptroller	$1,496 09

Expenditures.

1900.		
	By building and repairs	$1,496 09
Oct. 1.	Balance in Albany	$118 82

PARIS GREEN LAW, CHAPTER 113, LAWS 1898, APPROPRIATION 1898-1899.

Receipts.

To amount received from Comptroller..	$400 96
	$400 96

Expenditures.

Publications	$173 00
Salaries	227 96
	$400 96

Oct.	1. Balance in Albany	$475 14
1900.		

UNITED STATES APPROPRIATION, APPROVED MARCH 2, 1887.

To amount received from the Treasurer of United States for the fiscal year ending June 30, 1900......................	$1,500 00

Expenditures.

Contingent expenses..................	$64 99
Feeding stuffs.........................	73 90
Freight and express..................	50 37
Heat, light and water..................	121 14
Library	23 07
Live stock.............................	500 00
Postage and stationery...............	32 56
Scientific apparatus..................	58 79
Seeds, plants and sundry supplies......	385 74
Tools, implements and machinery......	2 50
Traveling expenses	186 94
	$1,500 00

PRODUCE SOLD.

Receipts.

1899–1900.	
To amount received for produce sold....	$223 20

Expenditures.

By amount remitted to Treasurer, State of New York........................	$223 20

FERTILIZER LICENSE, CHAPTER 955, LAWS 1896, AMENDED BY CHAPTER 687, LAWS OF 1899.

Receipts.

1899–1900.	
To amount received for fertilizer licenses	$11,700 00

Expenditures.

By amount remitted to Treasurer, State of New York........................	$11,700 00

FEEDING STUFF LICENSE, CHAPTER 338, LAWS OF 1893, AMENDED BY CHAPTER 510, LAWS 1899.

Receipts.

1899–1900.	
To amount received for feeding stuff licenses..............................	$2,550 00

Expenditures.

By amount remitted to Treasurer, State of New York........................	$2,550 00

All expenditures are supported by vouchers approved by the auditing committee of the Board of Control, and have been furnished the Comptroller of the State of New York.

WILLIAM O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1900.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

Gentlemen: I have the honor to submit herewith a report of the New York Agricultural Experiment Station for the year 1900.

It is a matter of sincere congratulation that I am able to report to you the completion of another year's work of an apparently useful character and unattended by any serious disappointments or disasters.

THE STATION STAFF.

Mr. Wendell Paddock, after serving the Station faithfully and efficiently for nearly seven years as Assistant Horticulturist, resigned his position on September 15th to accept the chair of Botany and Horticulture in the Agricultural College of Colorado. Mr. Heinrich Hasselbring, B. S. A., a graduate of Cornell University from the Course in Agriculture, and for a year assistant in botany at that institution, was appointed to fill Mr. Paddock's place. Mr. Hasselbring entered upon his duties November 1, 1900.

During the year, acting upon your authority, assistants have been appointed in the departments of Bacteriology, Chemistry and Entomology, as follows:

Lore A. Rogers, B.S., Assistant Bacteriologist, July 10th.

Andrew J. Patten, B.S., Assistant Chemist, August 1st.

Percival J. Parrott, A.M., Assistant Entomologist, August 1st.

Mr. Rogers graduated from the Course in Agriculture at the University of Maine in 1896, and as special preparation for his work spent two years in bacteriological studies, one at the University of Wisconsin and one at this institution.

*Reprint of Bulletin No. 195.

Mr. Patten was a graduate from the Chemical Course of the University of Maine in 1897, and for three years was Assistant Chemist in the Maine Agricultural Experiment Station.

Mr. Parrott graduated from the Kansas State University in 1897, and until his appointment to this staff was Assistant Entomologist at the Kansas Agricultural College.

Two members of the staff are now away on leave of absence, Mr. Edwin B. Hart and Mr. A. D. Cook. The former is studying in Europe and the latter at Cornell University.

BUILDINGS AND THE GENERAL CONDITION OF THE STATION PROPERTY.

The much needed appropriation for the erection of a Director's house was granted by the Legislature of 1900. Contracts for completing this building within the appropriation have been let and its construction is well under way.

The completion of the plan for the improvement which you adopted, requires that the building now occupied by offices and the living rooms of the Director's family shall be reconstructed internally so as to furnish convenient facilities for the entire administrative work of the Station and the library. It is to be hoped that means for doing this will be provided by the Legislature of 1901.

It may be said that in general the property of the Station is in excellent condition. The chemical laboratory which has been occupied nearly ten years without repairs will soon need more or less attention, and a partial reconstruction of the interior arrangement of the cattle barn should be accomplished.

FINANCIAL CONDITION.

The work of the Station has so developed during the last five years that it requires careful planning to bring the expenses of the institution within its present income, an income for which no increase has been asked of the State during the past six years, notwithstanding a considerable enlargement of our staff and activities. As a matter of fact, the annual appropriations for maintenance which are raised by taxing the citizens of the State are $10,000 less than they were previous to 1900, because the fer-

tilizer inspection, for which $10,000 was formerly appropriated annually, is now self-supporting.

There is no good reason why the income of the Station should permanently remain at its present amount. So long as our efforts can be enlarged and strengthened in the service of the agriculture of the State and to its satisfaction, it will be found profitable to increase the expenditures in the interests of our greatest industry. In consideration of its environment and opportunities and of the wealth and position of the commonwealth which maintains it, this Station is entitled to attain a leading position in its equipment and in the character of its work. The citizens of this State may well make it a matter of pride to insist that this high condition of efficiency be reached and maintained.

THE MAILING LIST.

At the present time the bulletins of the Station are distributed as follows:

Popular Bulletin List.

Residents of New York	33,163
Residents of other States	1,075
Newspapers	760
Experiment stations and their staffs	779
Miscellaneous	131
Total	35,908

Complete Bulletin List.

Experiment stations and their staffs	799
Libraries, scientists, etc	257
Foreign list	95
Individuals	1,282
Miscellaneous	131
Total	2,544

FARMERS' INSTITUTE WORK.

The members of the Station staff continue to serve as speakers at farmers' institutes under an arrangement which tends to economize time and energy. It is understood that such service shall not exceed a stated length of time and shall be confined to not more than two periods of absence from the Station. The reasons for such limitations as these are obvious.

INSPECTION WORK.

This department of activity is gradually broadening. The Station is now responsible for inspection along four lines; fertilizers, concentrated feeding stuffs, insecticides and the Babcock glassware used for commercial purposes at creameries and cheese factories. The first two lines are rendered self-supporting through the license fees required by law. For the maintenance of the two latter no provision is made except as special appropriations may be granted.

The requirements of the fertilizer law are very fully met by the trade. It is safe to say that few brands of fertilizers are illegally sold in New York. It is still more satisfactory to note that manufacturers are, as a rule, very careful to maintain the standard of their goods up to the guarantee.

All this is due to a general acquaintance with the terms of the law and to the recognition of the fact, through experience, that the legal restrictions are beneficial to both manufacturer and consumer.

The concentrated feeding stuffs law has been in operation but little more than a year. It has been complied with very cheerfully and promptly by the leading manufacturers and jobbers and there is evidence that it is growing in influence and favor. Without question its provisions will in time be as fully met as is now the case with the fertilizer law, and its beneficence will be as fully recognized.

The detailed results of inspection along all lines will be mentioned later.

EXPERIMENTS IN COÖPERATION WITH FARMERS.

Experience is demonstrating that one very useful, and even essential, means of carrying on a certain class of experiments is the coöperation with farmers. In this way conditions can be secured which are not available on the Station farm.

During 1900 experiments of a coöperative nature have been carried on as follows: The use of commercial fertilizers in growing potatoes, with H. L. Hallock, Jamesport, W. A. Fleet, Cutchogue, W. L. Jagger, Southampton, and R. H. Robbins, East Williston; the use of commercial fertilizers on onions, with Stephen Mars, Florida; prevention of cabbage rot, with D. White, Phelps; prevention of onion smut, with Stephen Mars, Florida; prevention of asparagus rust, with Arthur L. Downs, Mattituck; prevention of peach leaf curl, with George D. Robinson, Riverhead; treatment of apple canker, with Harry Chapin, East Bloomfield; prevention of San José scale by fumigation and spraying, with W. & T. Smith, W. & T. Cass and C. H. Darrow, of Geneva, C. W. Ward, Queens, White & Rice, Yorktown, and G. H. Scudder, Huntington; spraying orchards in bloom, with George H. Bradley & Son, Lake Road, J. B. Collamer & Son, Hilton, F. D. Gardner, Barker, and T. B. Wilson, Halls Corners; investigation concerning the degeneration of varieties and an experiment in chestnut growing, with W. D. Barns & Son, Middle Hope; fertilizing fruit tree blossoms by bees, with S. D. Willard, Geneva; irrigation of strawberries, with W. F. Taber & Son, Poughkeepsie. In all these cases the Station is given access to property and more or less control over it, and in some instances the parties mentioned assume partial responsibility in conducting the experiments. The officers of the Station are under obligation to the persons mentioned for cordial and faithful assistance.

THE RESULTS OF INSPECTION WORK.

Inspection of fertilizers.—The new fertilizer law has proved very efficient in diminishing the number of brands of fertilizers offered for sale. In 1900, 113 manufacturers paid license fees

and complied with the provisions of the law relative to 600 different brands. The number of brands registered in 1899 was 2268, offered by 190 supposed manufacturers.

The number of samples collected between April 5th and October 1st was 638, representing 450 brands, each manufacturer being represented by from 1 to 28 brands. The results of the inspection during the year show that few brands fell short of the guarantees to any important extent.

Inspection of concentrated feeding stuffs.—The concentrated feeding stuffs law practically became effective at the beginning of the year 1900. Eighty-two manufacturers registered their goods and paid license fees on one hundred and four brands. During the year many samples of feeding stuffs were selected at different points in the State, one hundred and four of which were analyzed, the results being published in Bulletin 176. The results of the inspection show that in the main the leading manufacturers are meeting their guarantees. It also appears that some feeding stuffs were sold illegally, which is not surprising in view of the short time during which the law has been in operation. There are evidences that the law is meeting with favor and that it is exerting a valuable educational influence.

Inspection of Paris green and other insecticides.—Twenty-seven samples of Paris green and other insecticides were taken and analyzed. The general result is to show a good quality of Paris green in the market. One brand was found to be wholly unfit for use. The law under which we are operating is seriously defective in several points and it is proposed to ask the Legislature of 1901 to amend it.

Inspection of Babcock test glassware.—The Legislature of 1900 passed a law requiring that all Babcock glassware used by creameries and cheese factories which buy milk on the basis of the Babcock test shall be examined by the Station and marked. During the year 2,259 bottles have been received, 76 of which were inaccurate. The new bottles were, as a rule, fairly correct, the largest variation being in those made in the early history of the test. Some bottles of that character showed a variation of one per ct. from the true scale.

DEPARTMENT OF BACTERIOLOGY.

The following work has been carried on by the bacteriological department with the active coöperation of the dairy expert on all points which called for a knowledge of practical conditions.

Fishy flavor in milk.—An outbreak of this trouble was traced to the milk of a single animal. This cow seemed in good health but the milk possessed this intensely disagreeable flavor when freshly drawn. By tainting all the milk with which it was mixed the product of this one cow had caused a marked falling off in the business of a city dealer. All trouble ceased when the milk of this one animal was rejected. No biological cause for the flavor could be discovered.

Bitter flavor in Neufchatel cheese.—An outbreak of the trouble in a factory was studied and found due to the activity of certain kinds of bacteria. By making cheese from samples of the milk of each patron the source of the trouble was located and removed.

Sweet flavor in Cheddar cheese.—Work upon this subject has been continued throughout the year. It has been found that while yeasts occur but rarely in clean-flavored cheese they are regularly present in considerable numbers in all cheese selected for our study by cheese experts as typical examples of sweet flavor. This opens up an entirely new field concerning the relation of yeasts to bad flavors in cheese and work is being continued along this line.

Rusty spot in Cheddar cheese.—Reports seem to show an increase in trouble from this source during the present year. The bacterium causing the trouble was isolated from the product of factories in three different counties and its action studied when it was introduced into the cheese vat. When cultures of the germ were mixed with the milk before adding the rennet, little discoloration of the cheese resulted; but when introduced into the vat after the curd was cut, the cheese became very red.

This would seem to indicate that the time of introduction is important, and that infection from the factory and utensils is a more probable source of harm to the cheese than introduction

directly through the milk of the patrons. Work upon this subject will be continued.

DEPARTMENT OF BOTANY.

A parasite of carnation rust.—It has been discovered that the carnation rust fungus is frequently attacked by a parasite fungus, *Darluca filum*. *Darluca* is a well-known parasite of rust fungi, but, heretofore, it has not been known that it attacks carnation rust. The parasite is not likely to be a very important factor in the control of the rust.

Anthracnose and stem rot of the snapdragon.—The cultivated snapdragon, *Antirrhinum majus*, is subject to a destructive fungous disease which spots the stems and leaves. It is called anthracnose and is caused by an undescribed fungus to which we have given the name *Colletotrichum antirrhini*. In an experiment on the treatment of this anthracnose, plants sprayed once a week with Bordeaux mixture continued in perfect health, while unsprayed plants in an adjoining row were completely ruined by the disease. Upon the results of this experiment we base the following recommendations: Spray thoroughly with Bordeaux mixture once a week, commencing as soon as the plants are rooted and continuing until they are put into the greenhouse in the fall. If later sprayings seem necessary use ammoniacal solution of copper carbonate instead of Bordeaux. Take cuttings only from healthy plants.

Stem rot is another disease of the snapdragon in which succulent shoots suddenly wilt and die. It has been shown by inoculation experiments that the cause of this trouble is a fungus belonging to the genus *Phoma*.

The sulphur-lime treatment for onion smut.—Smut is the most destructive disease of the onion. It kills large numbers of the seedling plants. During the past five years we have been conducting extensive field experiments in Orange County on the prevention of smut by the use of sulphur and air-slaked lime. Where these substances were scattered in the open rows before the seed was sown the yield was increased at the rate of from 40

to 100 barrels per acre. The results of the experiments were so satisfactory that we can unhesitatingly recommend the treatment for fields on which smut has caused a loss of as much as one-third of the crop. The proper quantity to use appears to be 100 pounds of sulphur and 50 pounds of lime per acre. It will not do to apply the sulphur and lime broadcast, as they seem to have no effect upon the smut when applied in that way. The application must be made in the open rows before, or while, sowing the seed.

Plant diseases caused by Rhizoctonia.—*Rhizoctonia* is a form-genus including several species of sterile fungi which cause root-rot, stem-rot and damping-off diseases of various cultivated plants. In Europe, considerable attention has been given to *Rhizoctonia* diseases, but in this country their investigation has been neglected, although it appears that such diseases are common here and some of them very destructive.

This Station, in coöperation with the Cornell University Agricultural Experiment Station, has undertaken an exhaustive study of *Rhizoctonia* diseases. A preliminary report of the investigations was published as Bulletin 186.

Fruit-disease survey of Western New York.—In the season of 1900 the Station made a fruit-disease survey of Western New York similar to the one made in the Hudson Valley in 1899. This survey has brought to light several new and important facts concerning fruit diseases. Among other things, it has been discovered that there exists in this State a destructive raspberry cane-blight which is caused by a fungus belonging to the genus *Coniothyrium*. This disease will be made the subject of a special investigation during the coming season.

DEPARTMENT OF ENTOMOLOGY.

The palmer worm.—The life history of this species, *Ypsolopus pometellus*, has been worked out during the past season. Apple leaves and young apples constitute the principal food of the caterpillars. Although well distributed throughout Western

New York the insect was most destructive in Wayne, Monroe, Orleans and Niagara Counties.

Fruit bark beetle.—Observations upon this species, *Scolytus rugulosus*, were begun last season and are being continued. It has been supposed that the beetles usually confine their attacks to sickly trees, but the past season's investigations have shown that they will also attack and deposit their eggs in healthy, vigorous trees. In some of the large peach orchards in Niagara County the beetles worked extensively in the bark of the trunks and large limbs, causing a copious exudation of sap. Cherry trees were also attacked, but to a less degree. Eggs and larvæ were found late in the fall in the sapwood of the smaller branches, into which the beetles had made short channels.

These habits of the insect indicate two methods of treatment: First, the application of a caustic wash to the bark and larger limbs during July; and second, the careful cutting out of the infested branches during the winter, as explained in Bulletin 180.

Quince mealy-bug.—A species of *Dactylopius* attacking quince trees. The life history of this species has been worked out in part. The studies will be continued until completed.

Wheat sawfly.—An investigation into the cause of "lodging" of wheat showed that a species of sawfly is probably responsible for much of the injury attributed to the Hessian fly. The sawfly larva feeds within the straw from the root to the head, but finally weakens it just above the crown of the root so that the wind causes it to break very low down. Hence wheat "lodged" as a result of the work of this insect lies close to the ground the full length of the straw. The kernels are but little affected. The insect passes the remainder of the summer and the winter in the crown of the root, appearing in the spring as a small four-winged fly.

The origin and early stages of parthenogenetic and sexual eggs of aphids.—These investigations have to do with some of the fundamental problems of insect development. They were begun a year ago, and are being continued. Up to the present time the details

of the formation of the polar body in the parthenogenetic egg have been worked out.

San José scale.—These investigations may be divided under two heads: (1) The development of the insect, and (2) the methods of control. During development the insect passes through three well-defined periods: (1) The period of activity; (2) the period of growth, and (3) the period of reproduction. The duration of all of the periods varied greatly with the temperature. During the active period the larvæ migrated readily over smooth surfaces. Numerous insects, representing five orders, were found from time to time with larvæ clinging to them. Ants, bees and wasps apparently do not carry them. During the period of growth the scale is formed. The average number of young produced per day by female of the fall broods was a little over two.

Experiments with kerosene oil, 100° fire test and 150° fire test, showed the former to be dangerous to the trees at the lowest percentage, when mixed with water, required to kill the scale. The latter gave similar results with peach trees and injured plum trees to a very slight degree when used strong enough to be effective to the scales. Apples and pears were uninjured. Experiments are also being made with crude petroleum and hydrocyanic acid gas. A fumigator for orchard trees has been devised which was successfully used in the experiments.

DEPARTMENT OF HORTICULTURE.

Fumigation of nursery stock.—The best known way of killing San José scale on dormant nursery stock is by fumigation with hydrocyanic acid gas. This treatment is valuable not only against San José scale, but against all scale insects which do not winter in the egg stage. It will doubtless also check the spread of some other kinds of injurious insects which are liable to be distributed on nursery stock:

Plain directions for fumigating dormant nursery stock with hydrocyanic acid gas are published in Bulletin 174 together with

suggestions as to the location and construction of fumigation houses or chambers.

Spraying fruit trees in bloom.—The effect of spraying fruit trees when in bloom with the common insecticides and fungicides which are used in orchards has been under investigation during the past season. The work was carried on both in the laboratory and in the orchard. In the laboratory the germination of pollen grains and the growth of pollen tubes in cultures which contained none of the poisons used in spray mixtures were compared with the germination and growth in cultures which contained either some insecticide or some fungicide, or both.

In these cultures both the Bordeaux mixture and copper arsenite of the strength commonly used in spraying apple orchards practically prohibited the germination of the pollen grains with which they came in contact. In cultures containing but 2 per ct. of the 1-to-11 Bordeaux mixture pollen germination occurred only in rare cases; while even the presence of only 1 per ct. of this mixture had a decidedly adverse influence on the germination of pollen and the development of pollen tubes.

In the field investigation an effort was made to learn what effect the spray mixtures have upon (a) the essential organs of the flower, (b) upon the yield of fruit and (c) upon the fungous diseases and insects which are injurious to the crop.

In almost all cases where the blossoms were hit in the center by the spray they failed to set fruit. In some cases the spray caused the stamens and pistils to wither prematurely. Occasionally when the spray hit the stigmatic surface the pistils remained green for an unusually long time awaiting pollination, but at last they withered and set no fruit. The laboratory cultures showed that the pollen could not grow in the presence of even quite dilute spray mixtures. It seems, therefore, that the spray mixture on the stigmatic surfaces, in the cases just cited, by preventing the growth of any pollen which may have reached the stigmas caused the blossoms to fall away without setting fruit.

Tests were made in four apple orchards besides those at the Experiment Station to see what effect spraying in bloom would have upon the insects and diseases which may be injurious to the crop and also upon the yield of fruit. The investigations gave no information as to whether or not the injurious insects and diseases may be controlled by spraying in bloom better than by earlier and later treatment, because the orchards under experiment were quite free from these troubles at spraying time.

Even with trees which had a great abundance of blossoms spraying in bloom decreased the yield on the average from one-third bushel to one and a half bushels per tree. Spraying trees at several different times while they were in bloom so as to hit both the early and the late blossoms with the spray ruined the crop of fruit.

Second report on New York apple-tree canker.—Since Bulletin 163 on the New York apple tree canker was published, Mr. Paddock has continued his investigations on this subject. He finds the fungus which causes this trouble, *Sphæropsis malorum*, occurs on several hosts, including apple, pear and quince fruits and apple, pear and hawthorn trees. Sunscald and sunburn undoubtedly have much to do with the susceptibility of some varieties of apple trees to the canker. The fungus which causes the canker in such cases undoubtedly gains entrance to the cambium through the tissue which has been injured by the sunscald or sunburn. In some parts of the country where sunscald and sunburn are much more injurious than they are in the apple-growing sections of New York State some make a practice of spraying trees in winter with whitewash to prevent sunscald, and train the trees to thick low heads to prevent injury in summer from sunburn. Mr. Paddock recommends spraying with Bordeaux mixture as a preventive of canker.

He has found that *Nectria ditissima*, which is a serious canker fungus in European orchards, occurs on apple trees in New York and Nova Scotia.

CROP PRODUCTION.

Experiments in plant nutrition.—During the years 1898 to 1900, inclusive, forcing house experiments were conducted relative to the much discussed substitution of soda for potash in plant growth. Several series of observations were made which were consistent within themselves and with the investigational results of the past. It was clearly shown that while soda may be substituted for potash in quantity, it cannot supply the place of potash in physiological function. Incidental observations raised the question of the necessary proportion of potash in the plant which is to be made the subject of future studies.

Commercial fertilizers in potato growing.—Experiments in potato growing conducted for four years on four Long Island farms with fertilizers varying in quantity from 500 pounds to 2,000 pounds per acre showed that on the average the largest profit was realized from the use of 1,000 pounds.

In comparing mixtures the so-called Long Island formula, 4, 8 and 10, proved to be superior to a potato formula 7, 4 and 10.

Other experiments with varying quantities of potash gave results which do not justify the use of such large quantities of this ingredient as are now being applied to potato growing by many Long Island farmers whose conditions are similar to those under which these tests were made.

One incidental result of these experiments was to make it clearly evident that a large supply of available plant food does not necessarily insure a satisfactory crop. Other conditions which largely pertain to culture, such as texture, humus and water supply, exercise a controlling influence, and when these conditions are unfavorable the situation is not overcome by heavy applications of fertilizer.

DAIRY DEPARTMENT.

Influence of the temperature of curing upon the quality of cheese.—The experiments in cheese-curing which have been conducted for two years have results of the highest importance from the commercial standpoint. Cheeses have been cured at temperatures

varying from 55°F. to 80°F., the higher temperatures representing the common factory conditions.

Of the cheeses made in 1899 those cured at 60°F. and below scored, on the average, almost 5 points higher on flavor and 2.5 points higher on texture than those cured at 65°F. and above. In 1900, the average difference in flavor of the lower temperatures was 5.1 points on flavor and 2.7 points on texture.

This is a matter well worth the attention of all cheese factory managers, because these differences in commercial quality are sufficient to cause important differences in the selling price.

BULLETINS PUBLISHED IN 1900.

No. 174. March.—Fumigation of nursery stock. S. A. Beach. Pages 8, figs. 2.

No. 175. April.—A parasite upon carnation rust. Frederick H. Blodgett. Pages 5, plates 3.

No. 176. September.—Inspection of concentrated commercial feeding stuffs during 1900. W. H. Jordan and C. G. Jenter. Pages 22.

No. 177. November.—Report of analyses of commercial fertilizers for the spring and fall of 1900. L. L. VanSlyke and W. H. Andrews. Pages 63.

No. 178. November.—Inspection of Babcock milk test bottles. W. H. Jordan and G. A. Smith. Pages 5.

No. 179. November.—An anthracnose and a stem rot of the cultivated snapdragon. F. C. Stewart. Pages 6, plates 3.

No. 180. December.—Miscellaneous notes on injurious insects: The forest tent-caterpillar; the fruit-bark beetle; a mealy-bug attacking quince trees; two apple-leaf miners; injury to peaches by the tarnished plant-bug. V. H. Lowe. Pages 22, plates 8.

No. 181. December.—A fumigator for small orchard trees. V. H. Lowe. Pages 6, plates 5.

No. 182. December.—Experiments on the sulphur-lime treatment for onion smut. F. A. Sirrine and F. C. Stewart. Pages 28, plate 1.

No. 183. December.—Notes on some dairy troubles: Flavor in milk and its products; fishy flavor in milk; bitter flavor in Neufchatel cheese; sweet flavor in Cheddar cheese; rusty spot in Cheddar cheese. H. A. Harding, L. A. Rogers and G. A. Smith. Pages 21.

No. 184. December.—The influence of the temperature of curing upon the commercial quality of cheese. Geo. A. Smith. Pages 9.

No. 185. December.—The New York apple-tree canker: Second report. Wendell Paddock. Pages 9, plates 4.

No. 186. January, 1901.*—The sterile fungus Rhizoctonia as a cause of plant diseases in America. B. M. Duggar and F. C. Stewart. Pages 30, plates 9. (In coöperation with Cornell University Agricultural Experiment Station.)

No. 187. December.—Commercial fertilizers for potatoes, III. W. H. Jordan. Pages 20.

No. 188. December.—Spraying for asparagus rust: I. Tests with resin-Bordeaux mixture. II. The Downs' power asparagus sprayer. F. A. Sirrine. Pages 48, plates 12.

No. 189. December.—A little-known asparagus pest. F. A. Sirrine. Pages 8, plates 1.

No. 190. December.—Report of analyses of Paris green and other insecticides in 1900. L. L. VanSlyke and W. H. Andrews. Pages 10.

No. 191. December.—A fruit disease survey of Western New York in 1900. F. C. Stewart, F. M. Rolfs and F. H. Hall. Pages 44, plates 7.

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*So dated to correspond with Cornell Bulletin 186, with which this is practically identical.

No. 192. December.—The substitution of soda for potash in plant growth. W. H. Jordan and C. G. Jenter. Pages 20, plates 6.

No. 193. December.—San José scale investigations. I. The development of the female. V. H. Lowe and P. J. Parrott. Pages 18, plates 6.

No. 194. December.—San José scale investigations. II. Spraying experiments with kerosene oil; methods of combating the San José scale. V. H. Lowe. Pages 16.

No. 195. December.—Director's report for 1900. W. H. Jordan. Pages 15.

No. 196. December.—Spraying in bloom. L. H. Bailey and S. A. Beach. Pages 62, plates 3, figs. 6.

W. H. Jordan,
Director.

New York Agricultural Experiment Station,
Geneva, N. Y., Dec. 31, 1900.

REPORT

OF THE

Department of Bacteriology.

H. A. Harding, *Bacteriologist.*
L. A. Rogers,[1] *Assistant.*

Table of Contents.

[1] Student assistant before July 10, 1900; assistant after that date.

REPORT OF THE BACTERIOLOGIST.

NOTES ON SOME DAIRY TROUBLES.*

H. A. Harding, L. A. Rogers and G. A. Smith.

SUMMARY.

The appearance of a highly disagreeable, fishy flavor in the product of a dairy was traced to the milk of a single apparently healthy cow. On rejecting the product of this animal no further trouble was experienced. No cause for the outbreak could be found.

An intensely bitter flavor in Neufchatel cheese was found to be connected with the activity of an acid forming bacillus. The bitter flavor was not reproduced in liquid cultures, but appeared upon draining and aerating the cheese curd.

The causal relation of certain yeasts to the production of undesirable flavors common in Cheddar cheese appeared probable from their constant presence in cheese showing sweet flavor and their absence in all those having a clean flavor.

The uniform reproduction of off-flavors when using pure starters of these yeasts in cheese-making tends still further to establish this relation.

Rusty spot in Cheddar cheese is caused by a bacterial growth. The addition of cultures of this bacillus to the vat before adding the rennet failed to reproduce the discoloration; but adding cultures of the same organism after cutting the curd gave a very marked case of rusty spot.

*Reprint of Bulletin No. 183.

INTRODUCTORY.—FLAVOR IN MILK AND ITS PRODUCTS.

In milk, and more especially in butter and cheese produced from it, flavor is the quality most noticed by the consumer. In milk the volatile compounds which impress themselves upon our senses are ordinarily spoken of as odors, while in butter and cheese they are usually included under flavor; although in the case of the expert, at least, they are determined in both cases by the sense of smell. In this discussion of flavor we will not attempt to distinguish between the impressions received through the ordinary act of smelling, as practised by the cheese judge, and the sensations received by tasting, in the case of the consumer. To be sure, in the latter act the sensations of acidity, bitterness and sweetness derived from the tongue are added to those received from the volatile compounds floating up to the olfactory membrane above.

SENSE OF SMELL NOT AN EXACT STANDARD.

Because the amount of this volatile matter is so slight we are without any exact standard of measurement, and in an attempt at careful work upon the subject recourse has been had to the sense of smell of a trained individual in order to judge the results obtained. When the work has to do with a very pronounced flavor of any kind this method gives satisfactory results; but when the presence of faint and complex odors is involved, as is the case with ripening cheese, the opinions of equally skilled and impartial judges often differ considerably.

In the past little work has been done upon this subject, except upon butter flavors, but there has grown up considerable information based upon isolated and more or less questionable observation.

TWO GENERAL CLASSES OF FLAVORS.

On the basis of their origin these flavors may be divided into two general classes—one directly connected with the growth of plant life in the milk, the other due to compounds taken up while in the cow or absorbed after the milk is drawn.

These two classes can usually be separated by observing the following points:

Troubles due to the action of bacteria, yeasts and molds are rarely noticeable when the milk is freshly drawn, but continue to increase with the lapse of time.

Troubles due to compounds existing in the food or developed in the body of the cow will be most marked while the milk is warm and will not increase on standing. When the odor is due to absorption the increase will cease as soon as the milk or butter is removed to an untainted place.

ABSORBED ODORS.

The danger of unpleasant flavors due to the cow has long been known and considerably overestimated. The effect of eating garlic, onions, etc., is unmistakable because of the highly-penetrating aromatic chemicals which find their way through the cow to the milk secreted. However, with the present rational ideas regarding feeding, it is unusual that the cow receives anything which will carry objectionable odors over into the milk.

A source from which we sustain much greater loss is that of vile odors aborbed after the milk has been drawn. This is a danger which is very real and yet for the most part entirely overlooked. Milk left for even a few minutes in the average stable air or poured into bad smelling cans or placed to cool in a tank of foul water will quite uniformly acquire a disagreeable smell which may not be noticed by the farmer, but when commented upon by the maker at the factory will be blamed upon the cow or something she has eaten.

Odors of this class are most noticeable in the milk and cream trade and are of less importance in the butter and cheese industry because there is more time and opportunity to remove them before the product reaches the consumer.

ODORS PRODUCED BY PLANT GROWTH IN THE MILK.

In the very nature of things odors of this class can not appear until the lapse of sufficient time to enable the bacteria, yeasts or

molds to grow in the milk and produce changes in its composition. This should not take place to an appreciable extent under twelve hours, and if the temperature is kept reasonably low, will not do so for a much longer period.

From this it will be seen that in the milk as it is ordinarily delivered in the milk trade of the smaller cities or at the factories there should be no odor due to plant growth. Whenever a disagreeable odor is present it can be ascribed either to aromatic substances absorbed or to holding the milk at too high temperatures.

This statement of the matter may at first glance appear to conflict with practical observation; for sometimes a certain odor becomes noticeable soon after the milk is drawn and appears to increase in the cheese curd. In this case it would be more in accord with the known facts to assume that the same class of bacteria which brought about the decomposition of the exreta in the barn and produced from them the vile odor which was absorbed by the milk also found their way into the milk itself and there, later, produced similar foul smelling compounds.

Under ordinary circumstances we can begin to reckon the twelve hours above mentioned, from the time the milk is drawn; but the interesting observations of Moore[1] and Ward[2] have impressed the fact that in some animals the bacteria work their way high up into the glandular tissue of the udder and continuously attack the milk as it is formed.

Animal and absorbed odors are to be avoided as far as possible, since they are never desirable. After they have once entered the milk aeration will assist in their removal. The process of pasteurization accompanied by a subsequent cooling of the milk by flowing in a thin sheet over a cold surface is recommended by some producers of fine dairy products as a means to the same end.

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[1] Moore, V. A., and Ward, A. R. Source of Gas and Taint-Producing Bacteria in Cheese Curd. Cornell Agr. Exp. Sta., Bul. 158, 1899.

[2] Ward, A. R. The Invasion of the Udder by Bacteria. Cornell Agr. Exp. Sta., Bul. 178, 1900.

HIGH TEMPERATURES HASTEN THE FORMATION OF ODORS.

While under proper conditions the plants found in milk should not, and in most cases do not, produce flavors in the milk during the first twelve hours after milking, the fact remains that occasionally milk is so strongly inoculated with germs from its surroundings or is held at such high temperatures that the production of odors is accomplished in a shorter time. Moreover when cream is placed at a favorable temperature for ripening or milk in the cheese vat is heated for "setting" at 85° F. (24° C.) or goes through the so-called "cooking" at 98° F. (36.5° C.) the conditions are here favorable for a very rapid multiplication of the already large number of germs present. To support this amount of plant life and growth there is a correspondingly rapid decomposition of the constituents of the milk with an accompanying formation of aromatic substances.

The flavors in butter, both good and bad, are believed to be due to bacterial activity, with the exception of the inherent flavor of the fat and of a few cases where the odors absorbed by the milk are so pronounced as to pass over with the butter-fat, or when butter is allowed to absorb odors from its surroundings.

FLAVOR IN CHEESE.

In cheese, particularly of the Cheddar type, where the ripening process extends over a long period, the problem of flavor becomes complicated. It has been shown by Babcock and Russell[3], and corroborated by other investigators[4], that cheese contains chemical ferments capable of slowly producing profound changes in the casein which forms a considerable fraction of the fresh curd. The compounds which are thus formed undoubtedly

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[3] Babcock, S. M., and Russell, H. L. Unorganized Ferments of Milk: A New Factor in the Ripening of Cheese. Wis. Agr. Exp. Sta., Ann. Rept., 1897, p. 161.

[4] Freudenreich, E. von. Ueber das in der Milch vohandene unorganisirte Ferment, die sogenannte Galaktase. Cent. f. Bakt., II Abt., 6: 332, 1900. Jensen, Orla. Studien über die Enzyme im Käse. Cent. f. Bakt., II Abt., 6: 734, 1900.

have flavors peculiar to themselves, and these flavors are the fundamental elements in what we designate as the flavor of the ripening cheese. In addition to these fundamental ones, there are special flavors in every cheese, on the basis of which it is classed as poor to extra, and these differences have not yet been accounted for solely on the basis of enzym action.

The present state of knowledge of the subject does not justify dogmatic statements as to the origin of those delicate and agreeable flavors which are so highly prized in cheese, but the trend of evidence favors bacterial activity.

YEAST AS A NEW FACTOR IN CHEESE FLAVOR.

A factor which in the past has been almost entirely ignored in work upon milk and cheese problems is the relation of yeast to the dairy industry. The occasional occurrence of yeasts in Cheddar cheese has been previously noted by a number of investigators, but the fact that they may at times play an important part in the matter of flavor has been very generally over looked.

As the result of investigations detailed in the following article on sweet flavor it is ascertained that yeasts probably play a considerable rôle in the production of certain objectionable flavors which are annually the source of great financial losses in the State of New York.

The real need of exact knowledge on a subject of so much practical importance as that of flavor is evident. The goal to be attained, particularly in the case of cheese, is a clear understanding of the causes which produce the most desirable flavor, and of the best manner of assuring their constant operation. In attaining this end those well marked objectionable flavors which appear only at intervals, and offer least resistance to an analysis of the conditions under which they have been produced, become the natural avenue of attack upon the larger problem.

The cases of fishy flavor in milk and bitterness in Neufchatel cheese herein described, may be taken as types of many of the sporadic troubles which perplex the dairyman. The methods

used in locating the source of trouble in each case were so simple that it is hoped many may profit by the suggestions and be inspired to help themselves.

With sweet flavor in Cheddar the situation is somewhat different. Here we have to deal with a trouble which is both widespread and of long standing in the State, where it produces annually a large economic loss. This trouble has found its way into some of the cleanest and best managed factories, and there it remains despite the exertions of some of the most careful makers. In the past their efforts have been paralyzed by an entire lack of information as to the nature of the cause of this trouble.

While the discovery of the true cause is naturally the first step, especially in a biological problem, it should be followed by a study of the place of residence or manner of constant introduction into the factory before attempting the third and most practical step—the formulation of practical methods of combating the trouble.

It is our hope to follow out each of these steps in the order given in our attempt at aiding in the control of this widespread evil.

In attacking problems calling for training along such diverse lines the Bacteriological Department and the Dairy Expert have joined forces for the general good; but each assumes the responsibility for the correctness of certain portions of the work. The Bacteriological Department is solely responsible for the isolation and preparation of the cultures and starters, and the judgment of the Dairy Expert has been relied upon in manufacturing the experimental cheese and in deciding upon the similarity of the flavors there produced to those of the troubles under investigation.

CARD OF THANKS.

Owing to the unsatisfactory nature of conclusions based on the sense of smell, we have improved every opportunity for obtaining the verdict of many of the cheese experts of the State, and in the matter of samples we have been very materially aided

by the representatives of the Department of Agriculture, as well as by the cheese buyers throughout the State. For these many courtesies rendered we desire to return our sincere thanks.

I. FISHY FLAVOR IN MILK.

In June, 1900, a milk dealer brought to the Station a milk sample having a rank, disagreeable odor and taste, as though it had been in close proximity to herring or other fish. The taint was so strong that the milk was of no commercial value, although coming from a dairyman of more than ordinary carefulness in the handling of his herd.

Within an hour the dairyman called, bringing a sample direct from the farm. Although this was saturated with the same odor, the producer protested in all good faith that he could smell nothing unusual.

METHOD OF LOCATING THE TROUBLE.

As the trouble was evidently located upon the farm, the dairyman was provided with a supply of sterile, self-sealing pint bottles and directed to collect a sample from each cow by milking directly into the bottle from each quarter in turn. The following morning the bottles were returned properly filled and numbered.

An examination by the nose showed that the trouble was limited to a single cow, and the dairyman was directed to reject the milk from this animal. The following day the milkman reported that the trouble had disappeared and that his supply was highly satisfactory.

A second set of samples at the end of three days gave the same result and showed that the trouble was stationary in the product of one cow. A visit to the farm threw no light upon the origin of the trouble. The pasture was a dry upland, containing no objectionable weeds as far as known. The feed and general treatment of all the cows had been the same, and they were all apparently in the best of health.

The odor of the milk was strong as it was drawn, and did not appear to increase on standing. This would incline one to the belief that the trouble was due either to the food or to the general condition of the animal; but no food has ever been known to bring about the flavor described, and all the food had been shared by the whole herd. Neither was there any discernible ailment or lesion of the cow, and the physical appearance of the milk was normal.

NO BIOLOGICAL CAUSE FOUND.

Considerable culture study was carried on in the laboratory with the milk from the different quarters of this cow's udder and several kinds of bacteria were isolated. When these organisms were grown separately or in mixture in milk they failed to reproduce the characteristic fishy odor. A form was found to be very plentiful in the strippings which was peculiar in that it refused to grow in the ordinary lactose agar or gelatin unless five per ct. to ten per ct. of milk was added. This organism was further tested by introducing a culture of it into two quarters of the udder cavity of a healthy cow, leaving the other two quarters as a control. The results of this test were also negative in that no odor was produced.

OTHER OUTBREAKS.

While a fishy flavor in milk is by no means a common trouble, Mr. W. E. Griffiths, one of the agents of the Department of Agriculture, informs us that he has observed two outbreaks of somewhat similar nature in the fifth district. In one instance June butter with a fine flavor was placed in cold storage at 18° to 22° F. until winter and when sold in the local market was returned with the complaint that it had a disagreeable flavor. Upon inspection by butter experts this was pronounced a fishy flavor. No cause could be found. The second case occurred in 1899, when a cow kept for family use gave milk which was so pronouncedly fishy in the odor arising from it and in the taste, that the milk was discarded during the latter part of July and the month of August. The milk as soon as drawn had this pe-

culiar flavor and did not seem to develop any more upon standing.

II. BITTER FLAVOR IN NEUFCHATEL CHEESE.

The bitterness in Neufchatel cheese which is here described should not be confused with the well-known bitter flavor in milk and cream. This latter is often produced in summer by the activity of digesting bacteria which by enzym action break down the chemical compounds of the milk into simple ones having a bitter flavor; and in winter by a different class which seem to thrive at temperatures lower than those favorable to the ordinary acid forming germs and produce the bitter flavor as one of the by-products of their metabolism. In either of these cases the objectionable flavor appears in the liquid.

In the case to be described the milk gave no outward sign of being abnormal and it was only when the manufacture of the Neufchatel had progressed to the stage of draining and aerating the curd that the bitterness became apparent. Since but a single outbreak has come to our notice a detailed description would hardly be called for except for the fact that the methods employed to get the maker out of his trouble were very simple, and can be easily applied to many of the other troubles which perplex the factoryman.

A sample of intensely bitter Neufchatel cheese was received in October, 1899. The maker stated that he had repeatedly scrubbed and scalded out everything that came in contact with the milk after it was received from the farm, but the trouble had persisted and ruined his product. The factory was visited and everything found acceptably clean; but the conditions for controlling temperature were not good. However, the temperature at that time was not unfavorable, and the trouble could hardly be ascribed to this cause. The milk that had been used for the Neufchatel was that of a single patron who had been selected because of the high fat content of his product.

METHOD OF DETECTION.

The following day samples from each patron's milk were taken in scalded milk jars by the maker, cooled, numbered and delivered at the Station in the afternoon. The samples were then heated to 70° F., rennet added and the milk held at 70° F. until morning. At the end of 18 hours all the samples were curdled normally except two. These showed much whey on top, considerable gas in the curd and had a bad smell. On draining the curd one of these developed a markedly bitter flavor. On reporting these facts to the maker it was found that this was from the very patron whose milk had been selected for making the original bitter cheese. The maker was advised to scald once more all the cans and cloths that had been used, and proceed with milk from a different source. He later reported that on following this suggestion the trouble disappeared.

DUE TO THE ACTIVITY OF BACTERIA.

Since the bitter flavor did not exist in the fresh milk, but only appeared a day or two later in the curd and for some time continued to increase in quantity it was evidently connected with some form of life.

Cultures made from the bitter cheese and from the samples of milk furnished a variety of forms of bacteria and molds, and these were tested by preparing a pure-culture starter of each, adding it to some fresh milk from our own dairy and making small Neufchatel cheeses. To make sure that any bad flavors found in these experimental cheeses were not due to anything contained in our own dairy several samples of the same milk were made into cheese without the addition of any starter.

These control cheeses and nearly all of the cheeses to which pure cultures of different kinds had been added, were free from any bitter flavor, but one form was found that quite uniformly gave bitter cheese under these conditions. This germ was a short bacillus, forming sufficient acid when grown in sterile milk to produce curdling in one or two days.

It did not form an enzym capable of producing a visible change in the consistency of the milk and when grown in pure culture no bitter flavor was produced even when kept for some weeks. The formation of bitter flavor by this organism seems to be intimately associated with the exposure of the curd to the air; since, under any of the conditions that were tried, the bitter flavor appeared slightly or not at all when a soft, poorly-drained curd was prepared; while in a dry, friable curd the bitterness was very evident. Although it was grown almost continually in milk the organism lost the power of producing bitter flavor after about six months and further experiments were necessarily discontinued.

In this particular instance of the bitter cheese the trouble having been found to arise not from the factory but upon the farm it would have been of considerable interest to locate more closely the source from which these germs gained access to the milk. However on being informed of the results of our work the producer became highly incensed at the idea that there could be anything amiss with his milk and the investigation was not carried any further. As a result we could not aid him by suggesting practical means of ridding himself of the trouble nor have we the data upon which to advise others.

III. SWEET FLAVOR IN CHEDDAR CHEESE.

WHAT IS MEANT BY SWEET FLAVOR.

As was intimated in the introductory chapter on flavor there is a class of off-flavors which appears especially during the spring and fall in the output of many of the factories in this State and bears the general title of "sweet flavor."

A conservative estimate places the annual loss from this source at $10,000.

When cheese experts are questioned concerning the matter they usually agree in dividing this trouble into at least two classes—"fruity" and "sweet"—while in individual instances many other terms are used. When samples are selected and

sent in by these experts the result is a collection of odors often having little in common and representing all gradations from a well-marked odor of pineapple to the beginning of putrid decomposition.

Partly because of this evident confusion in the use of terms among practical men and partly because of the general nature of the information which we are now able to give concerning the matter, the flavors of this group will be here considered together.

NO CAUSE FOR THE TROUBLE PREVIOUSLY KNOWN.

At the beginning of the investigation we faced the problem of a serious trouble so obscure in its origin that not even a plausible explanation had been suggested, and the maker was handicapped in his attempts at combating the trouble by the lack of anything tangible against which to direct his efforts.

METHOD OF WORK.

From the fact that this trouble appears after the cheese has been some time in the curing-room the idea that it is in some way connected with life seemed to offer a starting point for work. Samples were secured from a number of cheeses considered to be typical examples of this trouble and a careful separation of the flora of each cheese was undertaken. It was assumed that if there was any specific organism or class of organisms causing the trouble they would be found in all the samples examined. A comparison of the results of a number of such examinations showed nothing unusual in the flora, except that in every case there was a considerable number of yeasts present.

YEASTS NOT COMMON IN GOOD CHEESE.

The subject of yeasts in cheese has been studied incidentally by a number of investigators when going over the cheese flora, and while it is not improbable that they may function in the ripening of some of the soft cheeses[5] no one seems to have seriously con-

[5] Freudenreich E. von. Bakteriologische Untersuchungen über den Reifungsprocess des Emmenthalerkäses. Cent. für Bakt., II Abt., 1: 232, 1895.

sidered their relation to hard cheese other than to suggest that they may play a rôle in some of the gas[6] formation. Among all the examinations into the flora of cheese none have been carried on in a more careful manner than the one by J. Weinzirl[7] under the direction of Dr. H. L. Russell, and in a report upon the flora of six Cheddar cheeses, yeasts were mentioned only once, and in that case a bad odor had been noticed in the curd. Very recently Weinzirl[8] has reported the results of an examination of 50 different Cheddar cheeses from factories scattered through seven states of the Union as well as from Canada, and in only four cheeses were yeasts found. In three of these four cases the yeasts did not exceed one per ct. of the total flora.

In connection with the present investigation we have examined a very limited number of samples selected for us by experts as being clean flavored cheese, and in every case we have failed to find more than an occasional yeast among the thousands of bacteria.

YEASTS ALWAYS FOUND IN SWEET FLAVOR CHEESE.

Since beginning work in 1899 we have examined samples selected for us by cheese experts as showing sweet or fruity flavor, coming from thirteen factories located in seven different counties in this State, besides several samples of unknown origin received from commission men. In every cheese, yeasts were present in considerable numbers, and while strictly quantitative data were not obtained it is believed that they were rarely as low as one per ct., and often approximated 50 per ct. of the total flora.

Owing to the present undeveloped condition of the classification of yeasts we have not yet been able to reduce the collection of yeasts obtained in this way to the basis of varieties repre-

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[6]Adametz. Ueber die Ursachen und Erreger der abnormalen Reifungsvorgänge beim Käse. Cent. für Bakt., 1 Abt., 14: 527, 1893.

[7]Weinzirl, J. Bacteria in Cheddar Cheese Ripening. Thesis Univ. of Wis., 1896.

[8]Weinzirl, J. The Bacterial Flora of American Cheddar Cheese. Cent. für Bakt., II Abt. 6: 785, 1900.

sented, nor have we attempted to establish the relation between slight variations in the flavor of the cheese samples and variations in the yeast flora.

SWEET FLAVOR PRODUCED BY YEAST STARTERS.

In discussing the causal relation of any organism either to a disease or to a fermentation it was formerly the custom to ignore all other factors than the mere presence of the germ. The fallacy of this method of reasoning has come to be recognized in medical matters and our experience detailed below, as well as the results of our study of the activity of the organism producing rusty spot, shows that the accompanying conditions exert a profound influence upon the activity of fermentative organisms. The fact that sweet flavor in a factory undergoes seasonal and even daily variations in its activity would suggest the same idea. In beginning experimental work upon such an untried field as the relation of yeasts to cheese flavor, it is not surprising that the results have not been uniformly good. By referring to the article on rusty spot it will be seen that, while in a majority of attempts the use of a starter of the causal organism resulted in failure so far as a real reproduction of the typical trouble was concerned, yet when the right conditions were obtained this same organism reproduced the rusty spot in even more marked form than is met with in the factories.

The starter used with a majority of the cheeses made in this connection was prepared from a pure culture of a yeast which is designated in the laboratory as 2F. This yeast was isolated from a cheese showing a well-marked case of sweet flavor. In each of these experimental cheeses there was reproduced in a slight degree the characteristic flavor of the original cheese. The determination of this fact rests not only upon the judgment of one of us, but has been subscribed to by a number of experts to whom these cheeses have been submitted. However, it must be said in all fairness that the sweet flavor reproduced in these experiments fell short of the intensity often met with in fac-

tories, and would probably have been overlooked in a commercial transaction.

Before and during the time of these experiments the manufacture of cheese for other purposes was being carried on in the same room without any appearance of sweet flavor. A vat which had been used in making one of the yeast-infected cheeses, and had been cleaned in the usual manner, but without any special precautions, was again used, after an interval of two days, in making six Young America cheeses, which were distributed among the various curing rooms. Upon examination at the end of two months they were decided by a number of competent judges to show well-marked cases of sweet flavor. An examination at this time showed the presence of a goodly number of yeasts.

CONCLUSION.

"Sweet flavor," as the term is generally used, includes a group of undesirable cheese flavors. Clean-flavored cheese contains very few, if any, yeasts, while sweet-flavored cheese contains large numbers of yeasts, at least during the first stages of ripening.

The addition of starters of certain yeasts to the cheese vats has repeatedly resulted in the production of off-flavors, some of which would be included under the general term of "sweet flavor."

IV. RUSTY SPOT IN CHEDDAR CHEESE.

A discussion of rusty spot in Cheddar cheese may seem out of place in a bulletin otherwise given up to the subject of flavors; but since this is one of the annoying dairy troubles in the State, and has received considerable attention at the Experiment Station during the past two years, a short article upon this subject is given here.

WHAT IS RUSTY SPOT?

"Rusty spot" is the name given to small yellowish-red points or patches scattered quite evenly throughout the mass of the cheese and having the general appearance of iron rust. A closer

examination shows that a majority of these colored points are located on the walls of the small openings left by the incomplete union of the particles of cut curd or by the later formation of gas bubbles.

These points rarely become visible in cheese under eight days old, and gradually increase in size during the first two or three months. During the latter portion of this time the extension of these spots is probably not due to real growth, but rather to a mechanical spreading of the coloring matter along the surface upon which it has been produced.

This trouble is most common in spring and fall, appearing in May and disappearing in October; while in the case of a badly infected factory it may continue through the summer season.

The coloring matter does not seem to be in any way harmful to the consumer, and if a trade could be built up in variegated cheese, this might command an increase in price on account of its color. However, the present attitude of the market is quite the reverse, and the presence of these spots means a cut in the price and corresponding loss to the producer.

The only other trouble in hard cheese coming to our notice which might be confused with the one under discussion is a pink discoloration of the rind occurring either in isolated spots or in confluent patches. This latter is attributed to mold, and certainly has nothing in common with the genuine "rusty spot," which is confined to the interior and scattered throughout the mass of the cheese. A peculiarity which will illustrate the difference lies in the fact that when the rusty spots in cheese are brought to the air and light they fade from red through yellow, growing fainter until they finally disappear, while these pink discolorations are formed and continue on the exterior of the cheese, in direct contact with the air and light.

THE TROUBLE IS CAUSED BY A BACTERIUM.

From the fact that the spots cannot be seen in the young cheese, but appear later and continue to grow more evident for

some time, one would be led to suppose that the production of color is connected with the activity of some form of life in the cheese. The truth of this supposition was confirmed in 1897 by Connell,[9] who isolated from a rusty spot cheese an organism which he called *Bacillus rudensis.* He showed the causal relation of this bacterial form by using a starter made from it in the manufacture of cheese in which these rusty spots later appeared.

In our own experiments we have repeated this with organisms derived from outbreaks in different factories. The evidence seems to be conclusive that the red spots are produced by the growth of a minute plant which finds its way into the curd before it is put to press.

HOW DOES THIS BACTERIUM GET INTO THE VAT.

In the factory studied by Dr. Connell, the drain leading from the factory was found coated with a reddish-yellow slime which contained the organism causing the discoloration in the cheese. Upon giving the factory a thorough cleansing, washing the floor and woodwork with disinfecting solution, whitewashing the inside walls and replacing the wooden drain with an iron one, the trouble disappeared. From the fact that this attempt at disinfection covered all the available points about the factory, no substantial conclusion can be drawn as to the particular road through which the bacteria gained entrance to the curd. The one fact that seems evident is that in this instance the source of the infection was located at the factory rather than upon the farms.

In a number of New York factories an honest attempt has been made to meet all the demands of cleanliness and still this discoloration continues in the cheese. While the source of infection and methods of distribution of this trouble remained in

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[9] Connell, W. T. Discoloration of Cheese. Canadian Dept. of Agr., Bul., 1897.

such an unsatisfactory condition there was little inspiration for the factory men to take more vigorous steps for its removal.

In view of this incomplete knowledge of the subject and of the fact that some factories have suffered a considerable cut in the price of their output during a number of successive seasons, work was begun upon this line in the spring of 1899 and has been continued whenever opportunity offered since that time.

ISOLATION OF THE CAUSAL ORGANISM.

The first step was the isolation of the causal organism from affected cheese preliminary to the study of its behavior when introduced as a starter into a vat of good milk. Quite contrary to what would be expected from the published work upon the subject the isolation of the causal organism presented many difficulties. The red spots in the cheese are essentially colonies of the bacillus and the removal of a portion of one of these spots with a flamed needle gives approximately a pure culture, but in order to complete and make certain of the separation it is desirable to resort to plate methods.

Lactose agar does not prove suitable since, quite contrary to the ordinary rule, this organism refuses to produce color upon this medium; and no other basis of classification on agar is evident.

Gelatin plates seem to be but little more suited to the work because only at rare intervals is sufficient color produced in the colonies to characterize them. In some instances the germ even refuses to grow upon gelatin when transferred from a potato culture, portions of the material carried over from the potato lying dormant in the gelatin for more than a week, yet when returned to a fresh potato surface setting up a vigorous growth.

The culture media was for the most part made neutral to phenolphthalein with sodium hydroxide, but variations of acid and alkaline media have been tried with no better success.

Cooked potato offers a very suitable medium for growth and production of color. Cut into slices and sterilized in Petri

dishes it gives a broad surface for inoculation. A flamed needle touched to one of the red spots in a cheese and then drawn repeatedly over a couple of such surfaces rarely fails to give isolated colonies of the desired organism. Transfers made in like manner from these isolated growths to other potato slices usually gives quite homogeneous cultures, the purity of which may be later tested upon gelatin plates and other substances. Following this old method, which on account of its inconvenience has been discarded by bacteriologists for a generation, pure cultures have been obtained from outbreaks in a half dozen factories scattered from St. Lawrence County to Allegany County.

While the methods in use enable us to isolate the organism with comparative ease from the red spots in cheese where it is present in an almost pure culture they are very little use when the desired form is mixed with a variety of others; as is the case in samples taken from the factory and its surroundings. The attempt has been made in the laboratory to perfect methods for recognizing the causal organism when present in relatively small quantities as would be the case in the mixed milk from the vat or in the can of any patron provided it was derived from such a source. Thus far these efforts have not been crowned with a high degree of success.

Fine distinctions as to the manner of growth of cultures derived from such widely separated portions of the country will not be discussed at this time but will be reserved until work upon the whole subject has reached such a satisfactory stage as to justify a more extended treatment. Suffice it to say that all the cheese samples examined presented essentially the same general appearance and each could clearly be referred to a biological cause; so that we can feel fairly certain that we have to do with a definite biological trouble spread over a wide extent of territory.

PRODUCING RUSTY SPOT IN EXPERIMENTAL CHEESE.

While the attempt was being made in the laboratory to devise means of readily recognizing the cause of this trouble, cheeses were prepared in various ways using starters derived from in-

fected cheese with the aim of finding the habits of the causal organism. In all, a dozen infected cheeses have been made beside the appropriate controls.

Of these, three were made at different times each with the addition of a half dozen plugs drawn from a cheese thoroughly spotted with the trouble. These plugs were first rubbed to a thin paste with water and then added to the vat before it was set with the rennet. In each of these experimental cheeses the spots which developed were so widely scattered that they would have passed any but a very careful inspector, and these three trials may be put down as failures as far as the production of spots in the cheese is concerned.

Seven cheeses were made with the addition of a culture of the causal organism to the milk before adding the rennet, and these likewise failed to produce more than a few red points scattered through the mass of the cheese, and as far as practical considerations are concerned these can also be classed as a failure to produce anything approximating what is commercially known as rusty spot.

Two cheeses manufactured at different times and using cultures derived from outbreaks in different factories were made by adding a culture to the vat just after the curd had been cut. In each case the interior of the uncolored cheese within ten days was so abundantly filled with small red points that at first glance these colored points seemed to blend and give the entire cheese a high red color.

While these observations are too few to be relied upon as proving anything regarding actual conditions in the factory they are in many ways very suggestive. In the first place these experiments show that a cheese may contain a large number of the proper kind of germ and still not show any discoloration. This may throw some light upon the failure of the spots to appear in the make of certain days in an infected factory.

Again, these results suggest that the stage of the process when the germs enter the vat may be very important. When the milk is curdled by the rennet all these minute plants within the mass

are caught and held in the coagulum. It was to be expected that many of these would be liberated by the cutting and farther manipulation of the curd, but this does not seem to have occurred to any considerable extent in the above experimental cheeses.

It should be stated that to avoid contaminating our curd mill the cheese was all handled as stirred curd. It is generally agreed that this trouble is worse in home trade than in the more acid export cheese, and in all these tests the attempt was made to produce a low-acid cheese.

The differences in results with cultures can not be well attributed to differences in the cultures themselves, since in one case approximately equal quantities of the same organism were used in two cheeses made with an interval of about twenty days. In the first instance the culture was added directly to the milk before setting with rennet, while in the other cheese the culture was added immediately after cutting the curd. The first cheese gave only very faint evidence of discoloration, while the second was intensely colored by a multitude of closely set yellowish-red points.

CONCLUSION.

While we are not yet in a position to give the clear-cut information desired by the factorymen, still the following points may be of assistance:

The rusty spots in Cheddar are simply the growth of minute plants on the walls of the air spaces within the cheese. While the growth does not seem to be harmful to the consumer, it is objectionable because it is unsightly.

Coloring the cheese will cover up these spots, except in very bad cases.

High acid content, with the consequently small amount of moisture in the air spaces within the cheese, tends to keep down the production of color.

The trouble usually appears in May, often does little harm through the middle of the summer, and ordinarily disappears in October.

Specific directions for freeing a factory once infested cannot be given from the amount of data at hand, but plenty of hot water, followed by plenty of live steam on the vats, cans and working utensils, seems to be called for by the above experiences. We will be pleased to correspond with and, as far as practicable, visit every factoryman in the State having this trouble, in the hope both of learning something ourselves and of being of use to the maker.

REPORT

OF THE

Department of Botany.

F. C. STEWART, *Botanist.*

FREDERICK H. BLODGETT,[1] *Assistant.*

F. M. ROLFS,[2] *Student Assistant.*

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[1] Resigned April 1, 1900.

[2] Resigned Nov. 1, 1900.

REPORT OF THE BOTANIST.

A PARASITE UPON CARNATION RUST. *

FREDERICK H. BLODGETT.

SUMMARY.

The growers of carnations in America have been troubled since 1891 with a disease known as rust, *Uromyces caryophyllinus* (S.) Schroet. No marked success has followed the numerous attempts to check its development. Recently a natural check was noticed infesting the pustules of rust; this was the fungus, *Darluca filum* (Biv.) Cast. Possibly some benefit may be derived from artificially introducing this fungus into carnation houses, but it is not sufficiently abundant to be of great assistance in natural conditions.

INTRODUCTION.

The carnation industry employs many men and a large amount of capital and tends to concentrate about the large cities. Many varieties are grown, some healthy and robust, others diseased and sickly when similarly treated. One of the most common diseases is the rust, which manifests itself by producing blisters upon the leaves and stems from which a fine orange-brown powder escapes. The powder is formed of the spores of the fungus *Uromyces caryophyllinus* (S.) Schroet. There is no satisfactory method of controlling the rust when once introduced.

On many rusts there is present in the pustules a fungus which attacks the rust plant and lives upon it as the rust lives upon the host. This fungus, *Darluca filum* (Biv.) Cast., has been recently

*Reprint of Bulletin No. 175.

observed for the first time upon the carnation rust. In a greenhouse at Flatbush, Long Island, it has been found on the variety Gen. Maceo; and in each of three different greenhouses at Geneva on several different varieties. While not naturally very effective as a check, by the use of artificial cultures or inoculations some benefit may be derived from its presence.

THE PARASITE.

(*Darluca filum* (Biv.) Cast.).

This fungus is related to the Septorias and Phomas familiar to florists through the diseases they produce. In some way this fungus has become adapted to living upon the tissues of other fungi instead of deriving its nourishment solely from the host plant.

The presence of *Darluca* is best determined with the microscope. But in cases where the rust is badly infested, the dwarfed and evidently crippled development of the rust pustules indicates that something is wrong. At times there are dead areas, in which are scattered a number of very fine black specks; these are the pycnidia of the *Darluca*. In other cases the infested area is nearly black, and the pycnidia are abundant. A third type of infestation is visible only with the aid of the microscope; in this the pycnidia are scattered among the spores in the infested pustules, which otherwise appear normal. In any case the presence of the *Darluca*, as of the rust, is shown externally only when it reaches maturity and produces spores.

The spores of *Darluca* are two-celled and colorless. They are developed within pycnidia or flask-shaped fruit-bodies, which may be nearly spherical, or much elongated. When a ripe pycnidium is moistened, the spores are expelled in a thick rope, which holds together by the gelatinous covering of the cell walls of the spores.

The pycnidia are formed from a cluster of interwoven vertical branches of hyphæ. As the mass thus begun develops, a cavity is formed at the center, which enlarges until only a thin membrane is left as the pycnidial wall. From the interior of this

membrane short branches have been produced at the ends of which spores are formed. When ripe the spores drop from their stalks, and others are formed in their places.[2]

THE RUST.

Carnation rust is distinguished from other rust-colored troubles of the leaves by the presence of brown spores, which are liberated by the bursting of the "blister" in which they are formed. Each spore is normally capable of germinating and developing into a fresh spot of rust. Moisture and warmth are necessary to the best development of this fungus, hence warm, moist houses are more seriously infested than cool, dry ones growing the same varieties. Different varieties of carnations are subject to the rust in degrees varying with the variety. There seems to be some relation between the presence of "bloom" upon the leaves and immunity to the rust, as those varieties which have the most bloom are among those which rust but little. The rust usually does little real injury to the plant but in severe cases it may seriously check the natural growth of the host.

Once infested the plant continues to be rusted until destroyed. The hyphæ of the fungus penetrate the leaf and stem-tissue and produce here and there the pustules of spores, which are the visible evidence of the rust plant. Cuttings taken from a rusted parent produce rusted plants[3], indicating the presence of the fungus hyphæ in the actively growing portions of the plant. When the rust spores germinate they gain access to the interior of the leaf either through a stomate or some weak or broken spot in the leaf. From such a point as center the disease spreads through the cells of the host, securing the needed nourishment from these cells. It is now safe from any external treatment; any checks to its further development must be able to reach it within the tissues of the host and yet do no material injury to that host. Such a check is the fungus *Darluca filum.*

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[2] Sapin-Trouffy in Le Botaniste, 5: 51.

[3] Statement made by carnation growers of experience.

The spores germinate readily in water and produce germ tubes from either one or both cells, from any point of the cell wall. The hyphæ or germ tubes probably gain access to the interior of the rusted carnation leaf through a stomate. Once within and adjacent to the rust hyphæ, the parasitism begins and the two plants become closely interwoven. The growth of *Darluca* is most abundant close to the pustules of the rust. The leaf tissue beneath the infested spot seems filled with the hyphæ of the two fungi. Often a dark layer is developed at the original surface of the leaf, above which rise the spores and the pycnidia of the two fungi. The dark color may not be confined to a mere layer or band, but may extend to the whole of the dense mass of hyphæ, almost totally obscuring the structure of the carnation leaf.

The pycnidia are imbedded for two-thirds of their height among the spores of the rust, showing only the dark upper third when seen from above. The surface is smooth and rather shiny, and is marked with a fine irregular network of cells. At maturity an opening is formed at the apex through which the spores exude when wet. In the specimen figured (Plate III, fig. 3) a thousand spores were visible, and more were constantly issuing from the pycnidium at the left.

The same fungus infests the rust of the asparagus; and it may be that, either by growing garden asparagus in the houses or by spraying the carnations with water in which *Darluca* infested asparagus has been broken a sufficient abundance of *Darluca* may be obtained to check the ravages of the rust.

At the present writing it is not known to what extent rust may be checked by the *Darluca*. It can not be expected to eradicate rust from a greenhouse, but its influence is good and it is believed to be worth the florist's while to encourage its growth.

EXPLANATION OF PLATES.

PLATE I.—*1.* Darluca *infested carnation leaves. Natural size. 2. The same leaves enlarged three times. Purple spot at left (two leaves), dark spots in center and speck form at right.* Photographed with yellow color screen, by author.

PLATE II.—*Two* Darluca *infested leaves, enlarged six times, showing* Darluca *spots. The* Darluca *pycnidia are the black specks scattered among the rust pustules, as at D and D.′* From photograph by the author.

PLATE III.—*1. Two pustules of rust* (Uromyces caryophyllinus) *showing pycnidia of* Darluca filum *imbedded among the uredospores. 2. Isolated pycnidia of* Darluca *showing adherent filaments of* Uromyces; *showing also relative size of spores of* Darluca *and* Uromyces *and the variation in shape of* Darluca *pycnidia. 3. Gelatinous thread of* Darluca *spores. 4. Cross-section of a* Darluca *infested* Uromyces *pustule.* 5. Darluca *spores from gelatinous thread shown in Fig. 3.* 6. Darluca *spores germinating.* All figures on this plate drawn with the aid of the camera lucida.

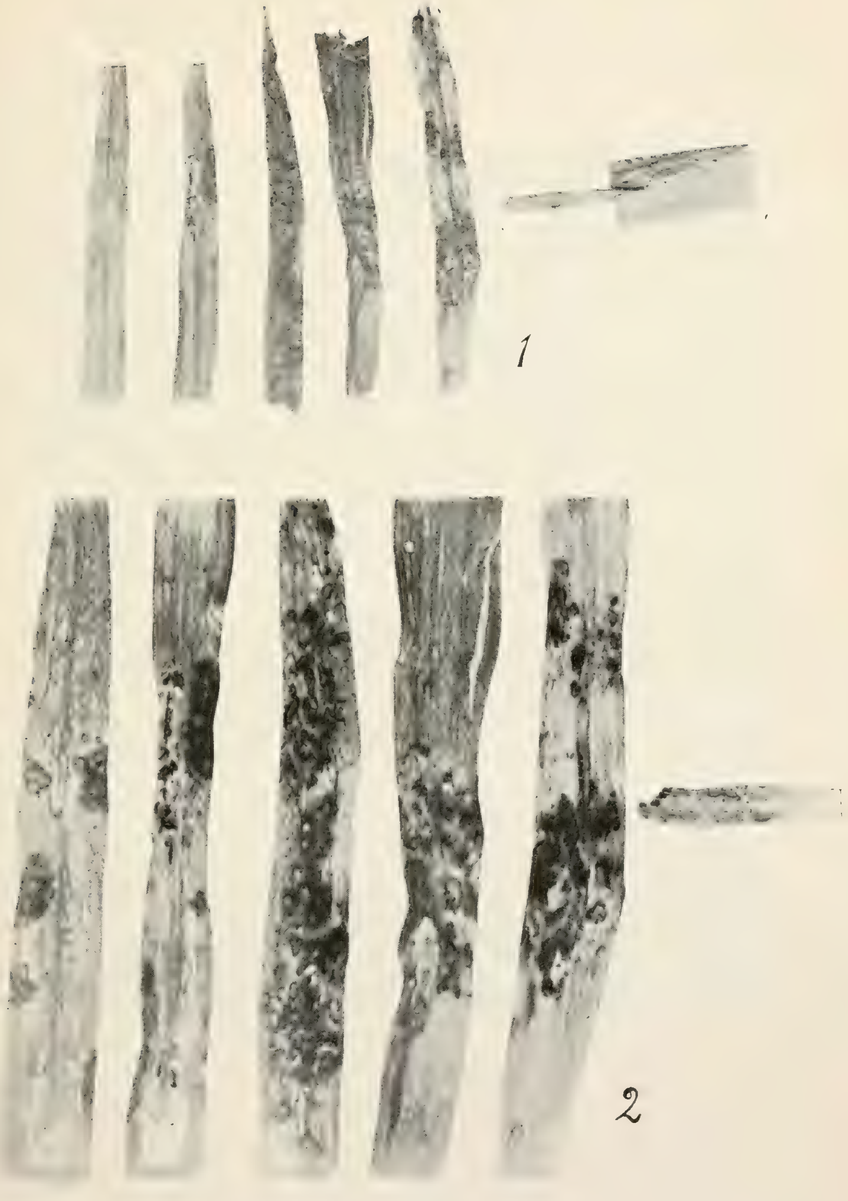

Plate I.

PLATE II.

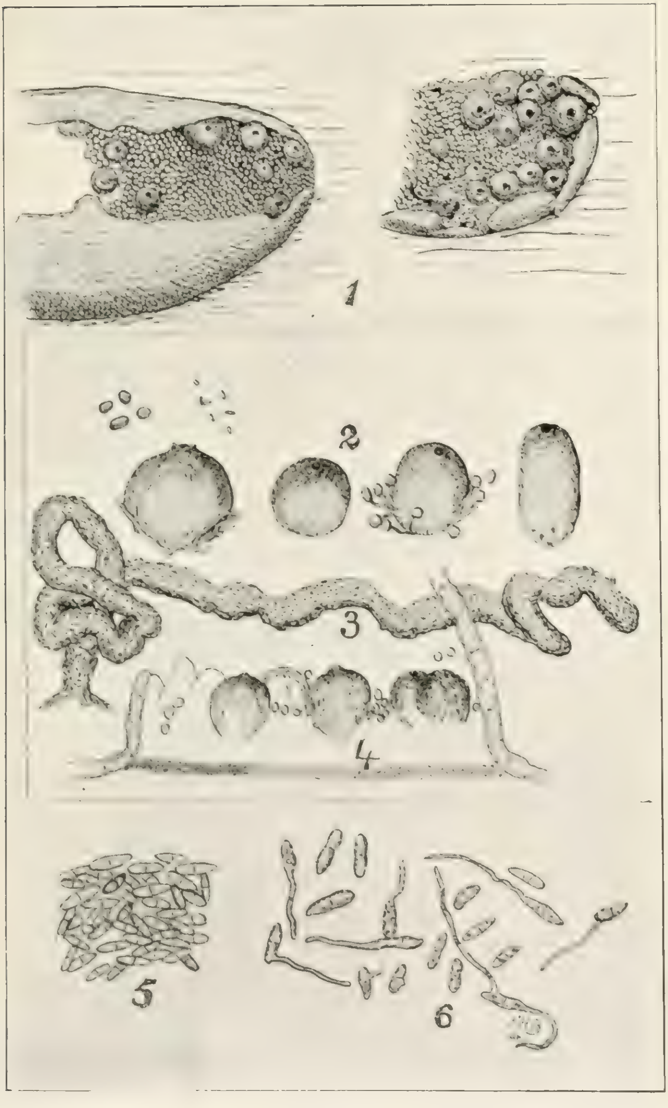

PLATE III.

AN ANTHRACNOSE AND A STEM ROT OF THE CULTIVATED SNAPDRAGON,

ANTIRRHINUM MAJUS L.[1]*

F. C. Stewart.

SUMMARY.

The cultivated snapdragon suffers severely from a fungous disease in which the stems and leaves are covered with elliptical or circular sunken spots. This disease is called anthracnose and is caused by a fungus new to science. The fungus is here fully described and figured and given the name *Colletotrichum antirrhini.*

In an experiment made on Long Island, plants sprayed once a week with Bordeaux mixture remained entirely free from the disease while unsprayed plants under parallel conditions were completely ruined by it.

It is recommended that cuttings be taken only from healthy plants and that the plants be sprayed with Bordeaux mixture, commencing as soon as the cuttings are rooted and continuing at intervals of from one to two weeks until the plants are put into the greenhouse in the fall. If later treatments are required ammoniacal solution of copper carbonate should be subsituted for the Bordeaux. The plants should be given good ventilation and the foliage wet as little as possible.

Stem rot is another fungous disease of less importance. It attacks the succulent shoots causing them to suddenly wilt and

[1]Read in abstract before the Botanical Section of the American Association for the Advancement of Science at the New York meeting, June 26, 1900.

*Reprint of Bulletin No. 179.

die. The diseased stems are covered with the pycnidia of a fungus belonging to the genus *Phoma*, and it has been shown by inoculation experiments that this *Phoma* is the cause of the disease. Although no experiments have been made it is probable that stem rot may be prevented by spraying with Bordeaux mixture as for anthracnose.

THE ANTHRACNOSE.

Early in the spring of 1897 the writer's attention was called to an anthracnose which was doing serious damage to a bench of *Antirrhinum majus* in a greenhouse on Long Island. Upon inquiry among florists it was learned that the anthracnose is a common disease, and wherever it occurs is more destructive than any other disease to which the Antirrhinum is subject, sometimes completely ruining an entire crop.

It attacks the plants at any stage of their growth, both in the greenhouse and in the field. In the greenhouse it is more destructive in the fall and spring than during the winter. In the field its ravages are most conspicuous in August and September.

On the stems it produces numerous elliptical sunken spots from three to ten millimeters in length; and on the leaves circular dead spots having a diameter of from three to five millimeters. These spots are caused by an undescribed species of *Colletotrichum* for which we here propose the name *Colletotrichum antirrhini*.[2]

ON THE STEMS.

Stems of all ages are attacked: The coalescence of several large spots may girdle the plant at the base; a single large spot

[2] *Colletotrichum antirrhini* n. sp. Producing depressed spots on stems and leaves of *Antirrhinum majus* L.; stem spots elliptical, often confluent, 3–10 mm. long; leaf spots orbicular, 3–5 mm. in diameter. Acervuli numerous and crowded, particularly on the stem spots; amphigenous on the leaf spots. Stroma well developed; on the leaves only slightly colored, but on the stems dark brown. Setæ abundant, especially on the stems, dark brown, 50–100 μ long, unbranched, mostly straight, tapering uniformly to a sub-acute point. Conidia 16–21 $\times$ 4 μ straight or slightly curved, with rounded ends or frequently obtusely pointed at one side of one end, granular with a vacuole at the center when young. Basidia short.

may strangle a succulent terminal portion; or the fungus may kill the lateral shoots while the main stem remains green. On the older woody stems the spots are considerably sunken, but on succulent shoots this character is scarcely noticeable. The spots are elliptical, their major axes having a length of from three to ten millimeters and lying parallel to the axis of the shoot. At first they are dirty white with a narrow brown border. In a short time several minute pimples, which are at first brown but soon turn black, appear in the central portion. Microscopic examination shows these pimples to consist of a brown stroma. Neither spores nor setæ are present at this time. It is in this black-pimple condition that the fungus is generally found. Still, under favorable conditions of moisture the spots fruit profusely; and both spores and setæ may be obtained in abundance at any time by placing spots showing the black pimples in a moist chamber for about 48 hours. However, very old spots may refuse to fruit under any conditions. With the appearance of spores and setæ the spots become quite black over the greater part of their surface. The acervuli are numerous and so crowded that it is difficult to distinguish the individuals even with the aid of a good magnifier. The stroma is dark brown and well developed.

Several setæ are borne on each acervulus. The majority of them are straight but some are bent. They are dark brown and taper uniformly to a moderately sharp point. As a rule they are 3-septate, but 2-septate and 4-septate individuals are not uncommon. They are 50 to 100 μ in length and unbranched.

The conida are non-septate, colorless and mostly about $4\frac{1}{2}$ times as long as broad, measuring 16–21x4 The majority of them are slightly curved, with both ends rounded or else with a short obtuse point at one side of one end (Plate VI, fig. 3). The young conidia have granular contents and almost invariably a single vacuole near the center; but with age more vacuoles appear and finally they become two to four nucleate. The writer's observations on plants in the greenhouse at Geneva lead him to believe that a high degree of humidity in the atmosphere is necessary

to the production of spores; but it is difficult to harmonize this idea with the statements of florists who say that the disease may be very destructive in dry seasons. During the extremely dry summer of 1899, a correspondent in Massachusetts lost, through this anthracnose, all field grown plants propagated from cuttings. It also did considerable damage to plants grown from seed.

The basidia are very short, being scarcely distinguishable except in very thin sections.

ON THE LEAVES.

Plants attacked by anthracnose show multitudes of dead leaves which remain hanging on the stems a long time.

The leaf spots are circular, slightly sunken and have a diameter of from three to five millimeters. They originate as yellowish-green spots with indefinite outline, but very soon become dirty white, or sometimes greenish, definitely outlined and very frequently have a narrow brown border. If the plants have good ventilation and are kept moderately dry neither spores nor setæ are formed and the spots retain their dirty white color; but in a moist chamber both spores and setæ make their appearance in from 24 to 48 hours. Upon the appearance of spores and setæ, the leaf spots instead of turning black (as is the case with the stem spots) merely become smoke colored. This is owing to the fact that the stromata of the acervuli are much lighter in color and the setæ much less numerous than on the stem spots. The stromata are also less developed than those on the stems.

AN EXPERIMENT ON TREATMENT.

From the nature of the disease it was expected that it could be prevented by spraying. Accordingly, the following experiment was made: On May 15, 1897, 110 Antirrhinum plants, six to eight inches high and apparently healthy were set in two rows of 55 plants each. On row was sprayed once a week with Bordeaux mixture, receiving in the course of the summer 17 applications, while the other row was left unsprayed for a check.

During the latter part of July the disease began to appear abundantly on the unsprayed row. By August 2d the contrast between the sprayed and unsprayed rows was very striking and as time passed this contrast became more marked until at the time of the last spraying, September 7th, the unsprayed plants were all ruined and most of them were dead, while the sprayed plants were in perfect health. (See Plates IV and V.)

RECOMMENDATIONS FOR TREATMENT.

Cuttings should be taken from healthy plants only. Anthracnose is often transmitted from one generation of plants to the next by means of infected cuttings; hence plants grown from cuttings usually suffer more from anthracnose than do plants grown from seed. It is very improbable that the disease can be transmitted by means of the seed.

So far as known at present, this anthracnose attacks no other plant besides the Antirrhinum. Therefore, the florist whose grounds are free from the disease will have no trouble so long as he propagates only from his own stock or from seed. In such a case the source of danger is in diseased cuttings and plants from other establishments. How far the disease may be carried by the wind is not known, but probably less than a half mile.

Where anthracnose is troublesome spraying with Bordeaux mixture should be commenced as soon as the cuttings are rooted and continued until the plants are transplanted into the greenhouse in the fall. The spraying should be done thoroughly and at intervals of from one to two weeks, according to the weather and the severity of the disease. If the plants can be kept free from disease until they go into the greenhouse, it may not be necessary to give them further treatment. Should it seem necessary to spray in the greenhouse, we would suggest the use of ammoniacal solution of copper carbonate, as it will not spot the flowers and foliage so much. Overwatering should be carefully avoided and the foliage wet as little as possible. Thorough ventilation will also aid in keeping the disease in check.

THE STEM ROT.

In December, 1898, we observed a stem rot or perhaps it might more appropriately be called a branch blight working among some Antirrhinums in one of the Station greenhouses. During the remainder of the winter and the following spring this disease became common and caused considerable damage. The same disease appeared again last winter, but not so destructively.

It attacks chiefly the succulent shoots, causing several inches of the terminal portion to wilt and die. In some cases, particularly on shoots which have become somewhat woody, a section of the stem an inch or more in length turns brown, while the portion beyond remains green. In a short time, however, the whole branch dies. More frequently all of the affected portion wilts and becomes discolored without the appearance of a spot at any particular place on it. The point of attack may be close to the soil, but is usually at considerable distance above it, and never below it so far as observed.

In all cases numerous pycnidia of a species of *Phoma* soon make their appearance on the lower part of the affected portion. In the course of the investigation other fungi were sometimes found on the diseased stems, but the *Phoma* was so abundant and so constantly present that it was suspected to be the cause of the trouble. Pure cultures of the *Phoma* were obtained and 11 succulent shoots inoculated with it, as follows: About three inches below the tip of each shoot a puncture was made, a small quantity of fungus inserted, and then the puncture covered by wrapping the stem with grafting wax. Ten check shoots were treated in identically the same manner, except that no fungus was inserted in the puncture.

The inoculations were made April 30th. At the end of five days four inoculated shoots were wilted; two more wilted on the eighth day, two others on the ninth day, and on the eleventh day all eleven inoculated shoots were fully wilted. Seven of them had rotted so badly at the point of inoculation that they had broken over and the tops hung down. As late as June 19th, seven weeks

after inoculation, all ten check shoots were perfectly healthy. On other occasions the *Phoma* has been inoculated into the shoots without covering the wounds with wax. Shoots so inoculated have generally died in from four to ten days, according to their succulency. Woody stems, however, do not readily succumb to inoculation.

The specific name of this *Phoma* has not yet been determined. The spores are colorless, 4-5 μ long by about 2 μ wide, and issue from the ostiolum in a colorless, gelatinous, rope-like mass. The fungus attacks woody stems with difficulty, but under suitable conditions it is an active parasite on tender shoots, and might easily become destructive. It could probably be controlled by spraying with Bordeaux mixture, as for anthracnose.

EXPLANATION OF PLATES.

PLATE IV.—*A sprayed plant of* Antirrhinum majus, *representing the condition, on August 13, of the sprayed row in the experiment described on page 64. A little more than one-third natural size.*

PLATE V.—*An unsprayed plant of* Antirrhinum majus, *representing the condition, on August 13, of the check row in the experiment described on page 64. A little more than one third natural size.*

The plants shown in Plates IV and V were not grown in the pots, but were put into them for convenience in photographing.

PLATE VI. FIG. 1.—*Portion of a stem and two leaves of* Antirrhinum majus *attacked by* Colletotrichum antirrhini. *Natural size.*

FIG. 2.—*A section of an acervulus of* C. antirrhini *from a stem spot. Drawn with the aid of a camera-lucida.*

FIG. 3.—*Five spores of* C. antirrhini. *Magnification, 780 diameters.*

FIG. 4.—*A seta of* C. antirrhini.

Type specimens of Colletotrichum antirrhini *have been deposited in the following herbaria: Herbarium of Cornell University, Ithaca, N. Y.; herbarium of the New York State Museum, Albany, N. Y.; herbarium of the New York Agricultural Experiment Station, Geneva, N. Y.; and the herbarium of the Iowa State College, Ames, Iowa.*

Plate IV.

Plate V.

Plate VI.

EXPERIMENTS ON THE SULPHUR-LIME TREATMENT FOR ONION SMUT.*

F. A. SIRRINE AND F. C. STEWART.

SUMMARY.

Where onions are grown extensively they often suffer from the attacks of smut, a fungus disease which kills the young seedlings or checks their growth.

The chief methods of combating smut are: (1) Transplanting; (2) rotation of crops; (3) use of larger quantities of seed; (4) the application of sulphur and air-slaked lime in the drills.

Transplanting is a certain and practical preventive, but there being considerable prejudice against it because of the labor involved, we undertook to develop Thaxter's sulphur-lime treatment. Extensive field experiments have been conducted at Florida, N. Y., during the past five years. These experiments prove that the yield of onions on smutty land may be greatly increased by the application of 100 pounds of sulphur and 50 pounds of air-slaked lime per acre in the drills at the time of sowing the seed. In several instances the yield has been increased at the rate of more than 15,000 pounds per acre, as compared with untreated plats.

Sulphur alone has considerable value as a preventive of smut, but seems more efficient when mixed with lime. It has been shown that the accumulation of sulphur in the soil in moderate quantity is not likely to be harmful. The sulphur and lime should not be applied broadcast, as they appear to have no effect upon the smut when applied in that way.

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*Reprint of Bulletin No. 182.

The sulphur-lime treatment is recommended whenever the loss from smut is as much as one-third of the crop. The treatment would be greatly facilitated and cheapened by the construction of a drill which will apply sulphur, lime and seed at one operation. It is further recommended that onion growers investigate the transplanting method; also try to develop the culture of some other crops to rotate with onions.

NATURE OF ONION SMUT.

Smut is a fungous disease which attacks onions grown from seed. The fungus causing it, *Urocystis cepulæ*, is related to the grain smuts, but different from them. So far as known the onion smut attacks no other plant than the onion. It kills great numbers of the seedling plants soon after they come out of the ground; and many other plants not killed outright by it are much injured, so that they die later or produce small and misshapen bulbs which are liable to rot.

If a seedling onion plant affected by smut be examined the affected leaves will be found to be not only enlarged but often distorted and if the smut is nearly mature the leaves will appear abnormally dark in color and often show black streaks. Upon breaking open the leaves they are found to contain a black powdery mass which is composed of the spores of the onion smut fungus. These black masses of smut spores also occur on the bulbs.

AMOUNT OF DAMAGE DONE.

Smut is, perhaps, the most destructive of all onion diseases and is common in nearly every section where onions are grown extensively. There are, however, localities where it is unknown. In this State it is very troublesome in the onion fields of Orange County while in the Madison County onion district it appears to be wholly absent.

It usually does not become destructive in a field until after onions have been grown for several years in succession. When onions are grown continuously on the same land the smut grad-

ually increases from year to year until finally it becomes so destructive that a profitable crop of onions can no longer be grown. Onion smut seems to be affected but little by weather conditions and is not subject to sudden fluctuations in virulence.

MODE OF DISSEMINATION.

Onion smut is chiefly a soil-inhabiting fungus. It rarely gets away from the soil except as it is carried on the bulbs. Unlike many fungi, its spores are not carried by the wind except, perhaps, for very short distances in times of heavy wind when considerable quantities of soil are moved.

It is not carried on the seed, but on the bulbs it may travel long distances. It is carried short distances, as for example, from one field to another in the same neighborhood or from one part of a field to another part of the same field, on tools used in cultivation, on crates, barrels and bags, on the feet of men and horses, with onion refuse used as fertilizer, and by the washing of the soil during heavy rains.

Many onion growers are accustomed to dispose of their onion refuse by spreading it on the land as fertilizer. This practice is to be condemned as it unquestionably serves to spread the smut. Unless it can be used on land not designed for growing onions or on land already thoroughly contaminated with smut (in which case the damage is inappreciable) it had better be allowed to go to waste. Especially is this true since the fertilizing ingredients in a ton of onions are worth only about 50 to 60 cents and a large part of this is lost by the escape of the nitrogen in decay.

METHODS OF COMBATING THE DISEASE.

BY THE USE OF LARGER QUARTITIES OF SEED.

When much smut is present in the soil the chief difficulty is to secure a "stand" of plants. To overcome this, onion growers are in the habit of using larger and larger quantities of seed as the smut increases year by year.

In extreme cases they use from two to three times as much seed as would be required on land free from smut. Finally, there comes a time when it is impossible to obtain a "stand" no matter how much seed is used.

ROTATION OF CROPS.

When smut becomes so troublesome that onions can no longer be grown with profit the land is planted to some other crop for two or three seasons. This treatment does not entirely rid the soil of smut but it reduces the amount somewhat so that for a few years following it is again possible to raise onions. In the Orange County onion district corn and potatoes are the crops most commonly used in such a rotation and it is there generally believed that corn is rather the more efficient in removing smut from the soil. Seeding the land down to grass for three or four years is also said to be somewhat beneficial.

How long it would be necessary to withhold onions from the soil in order that smut might entirely die out is not known, but it would certainly require many years. Some observations made by Dr. Thaxter[1] in Connecticut bear on this point. A field which had not grown onions for twelve years was sown to onions in 1888 with the result that from 10 to 50 per ct. of the plants became affected with smut.

While it is true that under some conditions onion smut spores may remain alive in the soil for a period of several years, it is the common experience of onion growers that even an occasional change of the crop for one or two years gives appreciable relief; and it is our belief that a systematic rotation of crops would very considerably reduce the amount of loss from smut.

BURYING THE SURFACE SOIL.

Various methods of burying the surface soil have been tried with varying success. One such method is deep plowing. This has sometimes given good results the first season but after that the smut is as bad as ever. Another method is to cover the field

[1] Thaxter, R. Ann. Rep. Conn. Agr. Exp. Sta. for 1889: 138–139.

with upland soil. This method can only be effective when the added layer of soil is sufficiently thick to prevent the smutty soil beneath from being brought to the surface in plowing. The expense of this treatment probably precludes its use.

A unique method of burying the surface soil has been carried out by Mr. J. J. Kelly of Florida, N. Y. He had a piece of land which had been cropped with onions continuously for thirty years. It became so smutty that only one-twentieth to one-tenth of a crop could be obtained even when as much as fourteen pounds of seed were used per acre.[2] He then conceived the idea of causing eight inches of the surface soil to change places with eight inches of the soil underneath. This was accomplished by first plowing a furrow eight inches deep, depositing it in a trench previously made, and then running the plow a second time in the same furrow, deepening it eight inches more and throwing the dirt over the first furrow. Care was taken to prevent as far as possible the mixing of the surface soil with the undersoil. The surface furrow was carefully leveled off with a shovel before the bottom furrow was thrown over it.

The chief difficulty encountered was the getting started. It was necessary to dig a trench eight inches deep and four furrows wide for a starting point; but Mr. Kelly thinks that another time he would use the drainage ditch[3] as a starting point, thereby avoiding the labor of digging a trench and at the same time disposing of weeds and grass which become troublesome along the ditch banks. When done plowing, the dead-furrows would mark the location of the new drainage ditches which would be already partly dug.

Another difficulty was found in the fact that it was impossible for a horse to walk in the deep furrow without miring. This was overcome by hitching to the middle of the plow beam in

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[2] About six pounds of seed per acre is considered sufficient on land free from smut.

[3] In the Orange County onion district the land is mostly divided into small fields of from one to five acres bounded by open drainage ditches, eighteen inches to two feet in depth.

such a manner as to make it unnecessary for the horse to walk in the furrow.

Once started, the job was not a difficult one. Mr. Kelly estimates that by using the ditches as starting points the expense of the work would be about $80 per acre.

This turning of the soil was done in the autumn of 1898. In 1899 the field was sowed with onions, and in spite of the fact that the crop was somewhat injured by drought, owing to the looseness of the new soil, the owner estimates that the increased yield on this one crop repaid him for doing the work. There was little if any injury from smut. The land was plowed shallow in the fall of 1899 and again sowed with onions in 1900. At the time of our visit, May 31, there was a prospect of a full stand of onions and only occasionally a plant showing smut. However, this small amount of smut still left in the soil will increase from year to year until after some years it will be necessary to repeat the operation. Then the question will arise, Are the smut spores in the deep-buried soil still alive? If they are it will do little good to turn the soil back to the surface again; but this point can be determined only by an experiment.

TRANSPLANTING.

More than ten years ago Dr. Thaxter[4] made the important discovery that smut can get into the onion plant only while the plant is very small. At the same time he observed that transplanted seedlings were free from smut. Six years later his successor, Dr. Sturgis,[5] made some experiments to determine if smut can be circumvented by germinating the onion seeds in soil free from smut and transplanting the plants into the field after they have become large enough to resist the attacks of the smut fungus. This was found to be true. It was shown that seedling onion plants reared in smut-free soil can be transplanted into smutty soil without contracting the disease. Here, then, is a

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[4] L. c., pp. 145–146.

[5] Sturgis, W. C. Nineteenth Ann. Rep. Conn. Agr. Exp. Sta., 1895: 176-182.

solution of the smut problem. But whenever this plan in suggested onion growers immediately exclaim: "It is not practical; it is too much labor to transplant onions!" We do not wish to enter into a lengthy discussion of the subject here, but we will say that experiments made at several agricultural experiment stations in different parts of the United States have shown that, even when smut is not a factor in the problem, the yield of onions can be greatly increased by transplanting, and that the method possesses certain other advantages which counterbalance the additional labor involved in transplanting. The idea originated with Mr. T. Greiner, of LaSalle, N. Y., who has put it into practice with great success and written a book about it. It is a subject worthy of investigation[6] by onion growers, especially by those who are having difficulty with smut.

THE SULPHUR-LIME TREATMENT.

In his experiments on the treatment of onion smut in 1889, Dr. Thaxter[7] tried several different chemicals which were applied in the drills at the time of sowing the seed. The best results were obtained where a mixture composed of equal parts of air-slaked lime and flowers of sulphur was used. Here, the yield of the treated rows was nearly five times as great as that of the same number of untreated rows alternating with them. The experiment was on a small scale. During the following season, 1890, another small experiment[8] with sulphur and lime gave practically the same results; namely, about five to one in favor of the treatment. A larger experiment was also planned, but on account

[6] For details as to methods and the results of experiments see: The New Onion Culture, by T. Greiner; Onions for Profit, same author; Bul. Ohio Agr. Exp. Sta., Second Series, Vol. III, No. 9; Bul. Tenn. Agr. Exp. Sta., Vol. V., No. 4; N. Dak. Agr. Exp. Sta. Bul. 12; S. Dak. Agr. Exp. Sta. Bul. 47; Tex. Agr. Exp. Sta. Bul. 36; Utah Agr. Exp. Sta. Bul. 45; Ark. Agr. Exp. Sta. Buls. 28 and 56; R. I. Agr. Exp. Sta. Bul. 14; Mich. Agr. Exp. Sta. Bul. 79; Wyoming Agr. Exp. Sta. Bul. 22; U. S. Dept. Agr. Farmers' Bul. 39; and Canada Exp. Farms Rep. for 1897, pp. 129–130.

[7] L. c., pp. 148–152.

[8] Thaxter, R. Further Experiments on the Smut of Onions. Ann. Rep. Conn. Agr. Exp. Sta. for 1890: 103–104.

of poor seed and unequal distribution of the fungicide the results obtained were unreliable.

Although the results of Dr. Thaxter's experiments plainly indicate that onion smut can be controlled to a large extent by the sulphur-lime treatment, and notwithstanding the fact that accounts of his experiments have been widely published, it appears that onion growers have made very little use of the treatment; and, so far as we can learn, no other experiments upon it have been reported.

OUR OWN EXPERIMENTS.

ORIGIN OF THE EXPERIMENTS.

At a Farmers' Institute held in Goshen, N. Y., in March, 1896, there was a lengthy discussion of onion smut and its treatment. One of the writers of this bulletin who was present took part in the discussion and read the account of Dr. Sturgis'[9] experiments on transplanting onions to avoid smut. The onion growers present were unanimously agreed that, in that locality, it was wholly impracticable to transplant onions. They were confident that the process would prove too expensive. Moreover, the market to which they cater requires small to medium sized bulbs suitable for boiling whole. Hence, an increase in the size of the bulbs due to transplanting would tend to reduce their market value rather than increase it.

As a result of the discussion a resolution was passed requesting the New York Agricultural Experiment Station to undertake some experiments on the treatment of onion smut.

We were then, and are still, of the opinion that transplanting as a method of circumventing onion smut is worthy of consideration by Orange County onion growers. However, as there was evidently a strong prejudice against transplanting and a desire for a less expensive treatment we decided to repeat Thaxter's experi-

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[9] L. c. Dr. Sturgis' paper was not yet published at that time, but he kindly loaned us the manuscript for use at the Institute.

ments with sulphur and lime. Thaxter's experiments were on a very small scale. We concluded to repeat them on a scale sufficiently large to enable us to determine whether the treatment is applicable to farm practice.

EXPERIMENTS IN 1896.

Experiments were commenced in the spring of 1896 and continued for five years. They were all made in the vicinity of Florida, N. Y., which is located in the midst of the Orange County onion district.

In 1896 one-half acre was devoted to the experiments. As we had, at that time, little acquaintance with the locality we were obliged to depend upon others for the selection of a suitable piece of land for the experiments. When the onions came up it was found that only a small percentage of the plants in the check plats were diseased—that is to say, the soil was not sufficiently impregnated with smut to make it suitable for an experiment on the treatment of the disease. Consequently, the results were of so little importance that it is not worth while to discuss them here.

EXPERIMENTS IN 1897.

For the experiments in 1897 another field was selected. This time we were more fortunate in securing smut-infested soil, but other difficulties were encountered. Some parts of the field were more diseased than others. The plats could not all be arranged so as to admit of close comparisons of yields. The available supply of air-slaked lime became exhausted before all the plats were sown; and this necessitated some changes in the original plan. A strong wind at time of sowing somewhat interfered with the uniform distribution of the sulphur and lime. The onion maggot, *Anthomyia ceparum*, caused unequal amounts of damage in different parts of the field. In consequence of these difficulties it is best to leave out of consideration a large part of the field and confine our attention to two series of plats covering a total area of 18,960 square feet, or a little less than one-half acre.

Series I.—Sulphur and Lime in Drills.

This experiment consisted of 12 plats, six treated and six untreated. Each plat was 15 by 50 feet and had an area of a trifle less than $\frac{1}{58}$ of an acre. The six treated plats were placed end to end. They covered 12 rows, which crossed them lengthwise. The six check plats were similarly arranged beside the treated plats and covered the same number of rows. (See diagram, p. 79.)

On the treated plats sulphur[10] and air-slaked lime, equal parts by weight, were scattered in the drills with the seed at the time of sowing. The quantity of sulphur and lime used varied on the different plats from 1,500 pounds per acre down to 125 pounds per acre. This was done to ascertain what quantity gives the best results.

The seed used was of the variety Red Globe and was sown April 13. When the plats were examined on June 12 it was very noticeable that the plants on the treated plats were taller, thicker and of better color. At the same time onion maggots were doing considerable damage at the north end of the field.

Series II.—Sulphur in Drills.

This series adjoined Series I. It consisted of eight plats, four treated and four untreated. Each plat was 15 by 83 feet, thus having an area of of an acre. The plats were arranged as in Series I. (See diagram on page 79.) On the treated plats sulphur alone was applied in the drills with the seed at the rate of 1,200, 1,000, 750 and 500 pounds per acre. The seed, variety Red Globe, was sown April 14. At the examination of the plats on June 12 it was observed that the plants on the treated plats were taller, thicker and of better color than those on the check plats. They compared very favorably with the plants on the plats treated with sulphur and lime in Series I.

[10] The sulphur used in our experiments has in all cases been the "flowers of sulphur," but we see no reason why the ground sulphur should not answer as well.

PLAN OF THE EXPERIMENT FIELD IN 1897. SHOWING SHAPE, ARRANGEMENT AND TREATMENT OF PLATS.

A Treated	C Treated	E Treated	G Treated	I Treated	K Treated
B Check	D Check	F Check	H Check	J Check	L Check

SERIES I. Plats 15x50 ft. Sulphur and air-slaked lime, equal parts by weight, in drills as follows:

A 1500 lbs, per acre.
C 1200 " " "
E 1000 " " "

G 500 lbs. per acre.
I 250 " " "
K 125 " " "

M Treated	O Treated	Q Treated	S Treated
N Check	P Check	R Check	T Check

SERIES II. Plats 15x83 ft. Sulphur in the drills as follows:

M 500 lbs. per acre.
O 750 " " "

Q 1000 lbs. per acre.
S 1200 " " "

RESULTS OF EXPERIMENTS IN 1897.

SERIES I.—SULPHUR AND LIME, EQUAL PARTS, IN DRILLS.

PLAT (1-58 a).	TREATMENT.	Yield in pounds. Per plat.	Per acre (computed)	Increase per acre due to treatment.	Percentage of increase.
A	1500 lbs. per acre......	588	34,151	5,924	21
B	Check	486	28,227		
C	1200 lbs. per acre......	559	32,467	10,135	45
D	Check	384½	22,332		
E	1000 lbs. per acre......	525	30,492	8,451	38
F	Check	379½	22,041		
G	500 lbs. per acre.......	516½	29,998	11,616	63
H	Check	316½	18,382		
I	250 lbs. per acre.......	416½	24,190	15,013	163½
J	Check	158	9,177		
K	125 lbs. per acre.......	438	25,439	14,810	139
L	Check	183	10,629		

Average yield of six treated plats.................. 507 lbs.
Average yield of six check plats.................. 318 lbs.
Average increase per plat due to treatment......... 189 lbs.
Average increase per acre due to treatment........ 10,977 lbs.

RESULTS OF EXPERIMENTS IN 1897.

SERIES II.—SULPHUR IN DRILLS.

PLAT (1-35 a.).	TREATMENT.	Yield in pounds. Per plat.	Per acre (computed).	Increase per acre due to treatment.	Per cent age of increase
M	500 lbs. per acre.......	821½	28,752	4,147	16.85
N	Check	703	24,605		
O	750 lbs. per acre.......	702½	24,588	2,818	13
P	Check	622	21,770		
Q	1000 lbs. per acre......	655½	22,943	7,193	45.67
R	Check	450	15,750		
S	1200 lbs. per acre......	536	18,760	6,825	57
T	Check	341	11,935		

Average yield of four treated plats................ 679 lbs.
Average yield of four check plats.................. 529 lbs.
Average increase per plat due to treatment......... 150 lbs.
Average increase per acre due to treatment........ 5250 lbs.

Comments on results of the experiments in 1897.—The results of the experiments in 1897 plainly show that onion smut may be prevented to a considerable extent by the application of sulphur

and air-slaked lime in the drills. On every treated plat in Series I the yield was considerably greater than on the adjoining untreated plat, the increase varying from 5924 pounds to 15013 pounds per acre; or in terms of barrels[11] from 40 to 100 barrels per acre. Certainly, this is a very creditable showing for the surphur-lime treatment.

The results in Series I indicate that the smaller amounts of 125 and 250 pounds per acre were more beneficial than the larger amounts; but these results are to be considered *only* as indications, because plats at the opposite ends of the field do not admit of close comparison with each other. That this is true is shown by the fact that the check Plat B at the south end of the field yielded 486 pounds while the check Plat L at the north end yielded only 183 pounds. Smut was more severe toward the north end and the onion maggot also caused more damage there.

The results in Series II show that sulphur, even when used alone, is tolerably efficient as a preventive of smut. Here, as in Series I, every treated plat yielded more than its adjoining check plat, and the difference varied from 2818 pounds per acre to 8193 pounds per acre; or from 18⅔ barrels to 54½ barrels per acre.

Since Series II adjoined Series I, there is reason to believe that the results obtained in the two series represent roughly the efficiency of sulphur and lime used together as compared with sulphur used alone.

In Series II the larger quantities of sulphur appeared to give the better results, which is in direct contrast to the results in Series I, where sulphur and lime were used together; but as has already been stated close comparisons can not be made between plats located at opposite ends of the field. The yield per acre on Plat S should have been quite as large as on Plat K because Plats K and S were in close proximity at the worst infested end of the field and their check Plats L, and T, gave approximately the same yield.

[11] In Orange County the onions are sold mostly by the barrel. A barrel of onions weighs about 150 pounds.

THE THREE YEARS' EXPERIMENTS—1898–1900.

Objects of the Experiments.

In the experiments of 1897 the best results were obtained where the smaller quantities of sulphur and lime, 125 and 250 pounds per acre, were used. This fact suggested the idea that perhaps the larger quantities of the mixture were in some way injurious to the growth of the plants. When the treatment is applied every year for a series of years a considerable quantity of the sulphur and lime must accumulate in the soil. Now the question arose, What will be the effect of repeated applications of sulphur and lime? If the accumulation of these substances in the soil injures the growth of the plants perhaps it will be better to use even smaller quantities than 125 pounds per acre. On the other hand, if such accumulation in the soil is *not* detrimental to the plants, may we not expect better results with the smut after the soil once becomes thoroughly impregnated with the chemicals? Hence, one object of these experiments was to determine the effect of repeated applications of the sulphur and lime.

The application of sulphur and lime in the row involves considerable extra labor. Why not save this labor by applying the mixture broadcast? Hence, a second object of these experiments was to determine the effect of broadcast applications of sulphur and lime.

For convenience we will hereafter call the experiments in which the chemicals were applied in drills Series I, and the experiments in which they were applied broadcast Series II.

Series I.—Sulphur and Lime in Drills.

Plan of experiments.—In the work of the previous two years we learned that onion smut is rarely equally destructive to all parts of a field. Often there are great differences in a distance of a few feet. In order to eliminate from an experiment the effect of such inequalities in the soil the plats must be long and narrow and duplicated several times. But since it was planned to continue the experiments for three years the plats must be

sufficiently wide to make it possible to relocate them after plowing. Accordingly, the field was divided into ten equal plats, each being $7\frac{1}{2}$ by 157 feet, having an area of $\frac{1}{37}$ of an acre. During three successive seasons, 1898 to 1900 inclusive, the plats were planted with onions (six rows 15 inches apart on each plat) and every alternate plat treated with sulphur and air-slaked lime applied in the drills at the rate of 100 pounds of sulphur and 50 pounds of lime per acre. The remaining five plats were left untreated for checks. Thus there were five treated plats and five untreated plats alternating with them. (See diagram on page 85.)

Notes for 1898.—The seed was sown April 23. On June 1 an attempt was made to determine the percentage of smut-infested plants on the various plats by taking a portion of a row containing 100 plants and noting the number which were smutty. These observations showed that on an average 64 per ct. of the plants on the treated plats were smutty, while on the check plats $91\frac{1}{2}$ per ct. were smutty. A similar count made on June 10 showed $41\frac{1}{2}$ per ct. of the treated plants and 75 per ct. of the untreated plants infested. It may be asked why the latter count shows a smaller percentage of infested plants. The answer to this question is as follows: Some of the affected plants enumerated in the first count had dried up and disappeared by the time the second count was made. Many of the diseased plants barely succeed in pushing their heads above the surface of the soil before they are killed, and the tissues, being very soft, decay and disappear quickly. The truth of this last statement is shown by the fact that to get 100 plants one must invariably cover a greater distance on a check row than on a treated row, notwithstanding the two rows received the same amount of seed. At best, such counts are only approximations, because it is impossible to avoid overlooking a good many of the affected plants.

The small yield in 1898 was due to a hail storm, during the latter part of July, and wet weather, which caused many of the bulbs to rot.[12] The crop was harvested August 10.

[12] For an account of the rot see Bul. 164 of this Station.

Notes for 1899.—This year the seed was sown April 25. On May 29, when the plants were showing their second and third leaves, counts were made to determine the percentage of smutty plants. The treated plats were found to average 20 2-5 per ct. of smutty plants and the untreated plats 72 4-5 per ct. At this time it was evident, even to a casual observer, that the treated plats were in considerably better condition, seemingly about 25 per ct. better than the untreated plats. The plants on the treated plats were larger and more numerous. The crop was harvested September 6.

Notes for 1900.—Seed sown April 27. A strong wind seriously interfered with the proper application of the sulphur and lime. On May 19 the plants were much injured by a dashing rain. Counts made May 28 showed the percentage of smut-infested plants on the treated plats to be 38½, and on the untreated plats 80. Counts made June 11 showed 31 per ct. of diseased plants on the treated plats and 52⅔ per ct. on the untreated plats. The earlier counts invariably show a larger percentage of smut and are the most reliable. By June 11 there was a marked difference in appearance in favor of the treated plats. The crop was harvested August 17.

M	Treated
N	Check
O	Treated
P	Check
Q	Treated
R	Check
S	Treated
T	Check
U	Treated
V	Check

SERIES I.—SULPHUR AND LIME IN DRILLS.

A	Check.
B	750 lbs. s.+375 lbs. l. 1 yr.
C	Check.
D	750 lbs. s.+375 lbs. l. 2 yrs.
E	Check.
F	750 lbs. s.+375 lbs. l. 3 yrs.
G	Check.
H	100 lbs. s.+50 lbs. l. 1 yr.
I	Check.
J	100 lbs. s.+50 lbs. l. 2 yrs.
K	Check.
L	100 lbs. s.+50 lbs. l. 3 yrs.

SERIES II.—SULPHUR AND LIME BROADCAST.

THE THREE YEARS' EXPERIMENT; SHOWING SHAPE AND ARRANGEMENT OF PLATS.

RESULTS OF THE THREE YEARS' EXPERIMENTS.

SERIES I.—100 LBS. SULPHUR AND 50 LBS. LIME IN DRILLS.

		YIELD IN POUNDS.								
		1898.			1899.			1900.		
PLAT (1-37a.)	TREATMENT.	Per plat.	Per acre (computed)	Increase per acre.	Per plat.	Per acre (computed)	Increase per acre.	Per plat.	Per acre (computed)	Increase per acre.
M	Treated..	161	5957	2534	883½	32,690	23,384	793½	29,360	7,807
N	Check....	92½	3423		251½	9,306		582½	21,553	
O	Treated..	131½	4866	3016	721	26,677	17,482	733½	27,140	19,037
P	Check...	50	1850		248½	9,195		219	8,103	
Q	Treated..	81½	3016	1240	676	25,012	12,802	437	16,169	9,218
R	Check...	48	1776		330	12,210		188	6,956	
S	Treated..	124½	4607	2498	456	16,872	7,714	587	21,719	9,694
T	Check...	57	2109		247½	9,158		325	12,025	
U	Treated..	80	2960	814	631½	23,366	15,485	814	30,118	12,302
V	Check...	58	2146		213	7,881		481½	17,816	

Average annual yield of the five treated plats......	487 lbs.
Average annual yield of the five check plats........	226 lbs.
Average annual increase per plat due to treatment..	261 lbs.
Average annual yield per acre of the treated plats..	18,035 lbs.
Average annual yield per acre of the check plats....	8,369 lbs.
Average annual increase per acre due to treatment..	9,666 lbs.

Discussion of results.—From an examination of the table above it will be seen that every treated plat yielded more than the adjacent untreated plat, and this was true for all three years. In 1899 the smallest yield on any treated plat (456 lbs.) was 38 per ct. larger than the largest yield on any untreated plat. (330 lbs.) Moreover, this increase in yield was not a trifling one. It varied from 814 pounds to 23,384 pounds per acre, and the average increase in yield, including all the plats and covering all three years, was 9,666 pounds or 64 barrels per acre. However, a brief study of the table is sufficient to show that this amount is surely smaller than the true measure of the benefit derived from the treatment. This is true because of the abnormally small yield in 1898. In that year the crop was injured at least 50 per ct. by hail and there was also considerable loss from rot. Leaving the season of 1898 out of consideration, the average annual increase per acre due to the treatment was 13,492 pounds or 90 barrels.

If we consider only the year 1899, the average increase per acre was 15,373 pounds or 102 barrels.

It will be observed that in 1899 and 1900 even the check plats gave a fair yield, showing that the disease was not nearly as destructive as it is sometimes. Had there been more smut present the difference between the treated and untreated plats would most likely have been greater.

Since the plats were of fair size ($\frac{1}{37}$ acre), very narrow, and duplicated five times, and the experiment continued three years, with the yield constantly in favor of the treated plats, it appears to us conclusively proven that sulphur and lime in the drills is an important aid in increasing the yield of onions on smutty land. This conclusion is further supported by the results of the experiments in 1897 (see page 80) as well as by Thaxter's experiments.

It is possible that the substances used have some value as fertilizer, but judging from the experiments in which sulphur and lime were applied broadcast it appears that their fertilizing value is at best but trifling. (See page 90.) That the treatment does actually prevent smut is shown by the fact that the untreated rows invariably showed a larger percentage of smutty plants.

Series II.—Sulphur and Lime Broadcast.

Plan of experiment.—This experiment was designed to show the effect of applying the sulphur and lime broadcast and also the effect of repeated applications. The field used was 340 feet long by 81 feet wide. It was divided crosswise into 12 equal plats, each $28\frac{1}{3}$ x81 feet and having an area of $\frac{1}{19}$ acre. (See diagram on page 85.) There were six treated plats alternating with six check plats.

On three of the treated plats 100 pounds of sulphur and 50 pounds of air-slaked lime (same quantity as used in the drills in Series I) were applied broadcast and harrowed in two or three days before the seed was sown. On one of these three plats the chemicals were applied only one year (1898); on one, two years (1898 and 1899); and on one, three years (1898, 1899 and 1900).

On the other three treated plats 750 pounds of sulphur and 375 pounds of lime were applied broadcast before the seed was sown; one plat receiving the application for one year, one plat for two years, and the third plat for three years, as described above.

The field on which this series of experiments was made lay to the east of Series I field, joining it at Plat L. The rows were run lengthwise across both fields; hence in Series II the rows ran crosswise the plats.

Notes for 1898.—The seed was sown April 23. The July hailstorm injured the plants very much, probably reducing the yield by 50 per ct.; and the accompanying heavy rain induced a bacterial rot which destroyed large quantities of the bulbs. The crop was harvested August 10.

Notes for 1899.—In the fall of 1898 the field was given a dressing of stable manure at the rate of eight wagon loads per acre, and then plowed. On April 24, 1899, the sulphur and lime were applied broadcast on Plats D, F, J and L. Plats B and H, treated in 1898, were omitted this year because they were to be treated but one year. The field was then thoroughly harrowed, after which it was smoothed by "planking." The seed was sown April 25 at the rate of 8 pounds per acre.

On May 27, Plat D (treated two years with 750 pounds of sulphur and 375 pounds of lime per acre) showed 36 per ct. of smutty plants against 38 per ct. on Plat C (untreated). On Plats D and F the stand of plants was thin, indicating that the sulphur and lime had been injurious to the seedlings. The crop was harvested September 6.

Notes for 1900.—Field plowed in the fall of 1899. The following spring commercial fertilizer was applied to the whole field at the rate of 500 pounds per acre. April 20, sulphur and lime were applied broadcast on Plats F and L only, and the field harrowed. On Plats D and F the sulphur applied to them in 1898 and 1899 was still plainly visible. The seed was sown April 27 and the crop gathered August 17.

Results of the Three Years' Experiments.

Series II.—Sulphur and Lime Broadcast.

Plat (1-10a.)	Treatment. Quantities given are per acre.	Yield in Pounds. 1898. Per plat.	Per acre (computed)	Increase per acre.	1899. Per plat.	Per acre (computed)	Increase per acre	1900. Per plat.	Per acre (computed)	Increase per acre.
A	Check......	176	3344		1283	24,377		981½	18,705	
B	750 lbs. s. +375 lbs. l. 1 year.	154½	2935	—409	1114	21,166	—3211	897½	17,052	—1653
C	Check......	188	3572		1125	21,375		816½	15,513	
D	750 lbs. s. +375 lbs. l. 2 years.	187	3553	—19	1171½	22,258	883	852½	16,197	684
E	Check......	178	3382		1031	19,589		818½	15,551	
F	750 lbs. s. +375 lbs. l. 3 years.	178	3382		1032	19,608	19	718	13,612	—1909
G	Check......	137	2603		743	14,117		978½	14,791	
H	100 lbs. s. +50 lbs. l. 1 year..	161½	3068	465	798½	15,171	1054	786	14,934	143
I	Check......	185½	3524		828½	15,741		788½	14,981	
J	100 lbs. s. +50 lbs. l. 2 years.	148½	2821	—703	876	16,644	903	776½	14,753	—228
K	Check......	155	2945		691	13,129		750½	14,259	
L	100 lbs. s. +50 lbs. l. 3 years.	149	2831	—114	857	16,283	3154	739	14,041	—218

Average annual yield of check plats A, C and E.................... 733 lbs.
Average annual yield of treated plats B, D and F.................... 700 lbs.
Difference in favor of check plats.................................... 33 lbs.
Average annual yield of check plats G, I and K.................... 562 lbs.
Average annual yield of treated plats H, J and L.................... 588 lbs.
Difference in favor of treated plats.................................... 26 lbs.

Discussion of results.—Because of the shape of the plats, the influence of variations in the original amount of smut and soil conditions was not so completely eliminated as it was in Series I. Hence the results obtained in Series II are less reliable than those obtained in Series I; that is to say, that where there is a difference in yield between a treated plat and its check that dif-

ference may be not wholly due to the treatment but partly the result of differences in soil conditions, insect injuries, or original amount of smut on the two plats.

The figures in the table on the preceding page seem to show that the broadcast application of the sulphur and lime had little, if any, effect on the yield. With one exception (Plat L, 1899) the differences in yield between treated and untreated plats were comparatively small. With the exception noted these differences may easily have been due to differences in soil conditions, etc. Moreover, the results are not consistent with themselves. It is impossible to find any system among them. For example, Plat J, which received applications of the smaller quantity for two years, showed a loss of 703 pounds per acre in 1898, a gain of 903 in 1899, and again a loss of 228 pounds in 1900.

It appears that where sulphur and lime are applied in small quantity, as, for example, 150 pounds per acre, there is little danger of harmful results from the accumulation of the substances in the soil. This is best shown on Plat F, where the substances were applied at the rate of 1,125 pounds per acre for three consecutive years without materially affecting the yield. In 1898 this plat yielded exactly the same as its check; in 1899 it yielded 19 pounds per acre more than its check; in 1900 there was a loss of 1,909 pounds per acre, which may or may not have been due to the treatment. Granting that it was due to the treatment, the amount is small as compared with the increase in yield resulting from the use of small quantities of sulphur and lime in the drills.

This experiment also proves that the increase in yield where sulphur and lime are applied in the drills is not due to any fertilizing value of the substances. Had the substances any considerable value as fertilizer the treated plats should have uniformly yielded more than the untreated plats, especially Plats B, D and F where the large quantities were used. But such was not the case. The three heavily treated plats averaged 627 pounds per acre *less* than their check plats.

FIG. 1.—SEED DRILL IN OPERATION.

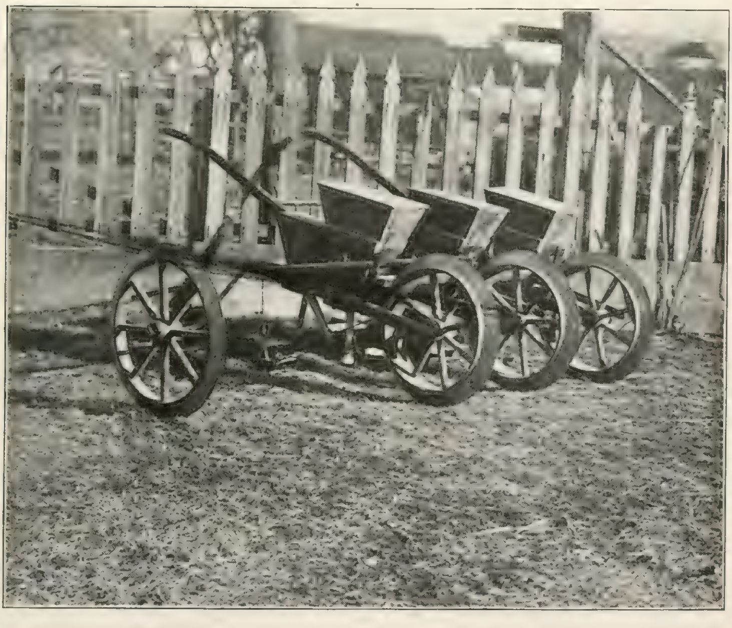

FIG. 2.—ATTACHMENT OF BOXES AND OUTLET SPOUT.

PLATE VII.—SEED DRILL WITH ATTACHMENT FOR DISTRIBUTING SULPHUR AND LIME.

HOW TO APPLY THE SULPHUR AND LIME.

Since it seems proven by the foregoing experiments that the broadcast application of sulphur and lime can not be successfully substituted for the application in drills the question arises, How is the application in drills best accomplished? In our experimental work we found the application of the sulphur and lime a difficult problem. In 1897 we proceeded as follows: The rows were first opened by using the seed drill with the coverers lifted and the seed boxes empty. The sulphur and lime (which had been previously thoroughly mixed) were then scattered in the open rows by hand. after which the seed was sown by running the seed drill over the rows.

In 1898 the rows were first opened by means of a home-made wooden marker, the sulphur and lime applied by hand and the seed then sown by a drill made to follow the open rows.

The application of the sulphur and lime by hand in this way involved considerable extra labor. Moreover, the sulphur and lime were not brought into as close contact with the seed as seems necessary for the best results; because when the drill passed over the rows the second time to sow the seed the chemicals were mixed with the dirt to a considerable extent. It was plain that both of these difficulties would be obviated by a drill rigged to sow sulphur, lime and seed all at one operation; so we had a seed drill for this purpose constructed by a local mechanic.

As shown in Plate VII, this machine was constructed on the same lines as the ordinary three-row drill used on the Florida "meadows" except that considerable space was left between the wheels and seed boxes for the attachment of boxes to carry the sulphur and lime. The latter were placed in front of the seed boxes in order that the sulphur and lime might fall in the open row ahead of the seed and also to bring the weight as near to the wheels as possible.

The apparatus for regulating the quantity of mixture to be applied was the same as that used on the seed boxes for regulating the application of the seed. Each box was provided with two

sets of agitators to prevent banking and clogging, and as a further precaution the sides of the boxes were made nearly perpendicular; but in order to get as much carrying space as possible the front ends of the boxes were slanted over the wheels. This proved to be a mistake as it favored banking. The front of the boxes should be perpendicular.

The outlet spouts were made uniform in size throughout their entire length and stood nearly perpendicular when in use—another precaution to prevent clogging. To secure uniform distribution of the mixture in the row each spout had a cone-shaped bridge below the outlet. (See Plate VII, Fig. 2.) It is desirable to have the mixture scattered along the sides as well as in the bottom of the furrow, so that the coverers in passing will draw it over the seed.

We have used this machine for two years with fairly satisfactory results and certainly with much more uniform results than could have been obtained by the hand application of the mixture. The important features of uniform and rapid application are furnished by this machine, but many improvements can be made upon it by careful and neat workmanship. The agitators are heavy, bungling affairs, with considerable lost motion. The sulphur-lime boxes should be larger and made of light material; and the arrangement for opening and closing the slots which regulate the quantity of material sown should be made so strong that it will not bend when used. It is probable that the manufacturers of garden tools could make a machine on the same lines which would work to perfection and thus make the sulphur-lime treatment an inexpensive method of controlling onion smut.

SOME OTHER EXPERIMENTS.

EXPERIMENT TO DETERMINE STAGE OF GROWTH AT WHICH INFECTION OCCURS.

Reference has already been made (page 74) to Thaxter's experiments, which proved that infection takes place below ground and while the plant is very young; also to Sturgis' experiments on transplanting onions, in which it was shown that onion seed-

lings germinated in smut-free soil do not contract the disease when transplanted into smut-infested soil.

The following little experiment made by us in 1900 confirms the results obtained by Thaxter and Sturgis. In a garden at Jamaica, Long Island, where onion smut had never been known to occur, we planted onion seed in eight rows each ten feet in length. A quantity of smut-infested soil was brought from Florida, N. Y., and applied to four of the rows, as follows:

Row 1. Smutty soil sown in the open row before sowing the seed;

Row 2. Check;

Row 3. Smutty soil sown in the open row after the seed was sown, but before it was covered;

Row 4. Check;

Row 5. Smutty soil sown over the rows immediately after the seed was covered;

Row 6. Check;

Row 7. Smutty soil sown over the rows 11 days after the seed was sown—just after the seedlings began to appear above the surface of the soil;

Row 8. Check.

The seed was sown May 2. There was rain on the morning of May 3 and again on the evening of May 8.

In Rows 2, 4, 6, 7 and 8 none of the plants became infested with smut; in Rows 1 and 3 there were very many smutty plants; and in Row 5 a few smutty plants.

The results of this experiment indicate that by the time the onion seedlings reach the surface of the soil they are immune to the attacks of smut. The few smutty plants in Row 5 are to be accounted for by supposing that the rain of May 3 carried some of the smut spores down to the germinating seeds. In the case of Row 7 it is very improbable that the failure of the plants to become infested was due to the lack of suitable conditions for spore germination; because light rains fell May 13, 15, 16, 17 and 18; on May 19 there was a heavy rain.

EXPERIMENTS ON COATING THE SEED WITH FUNGICIDES.

All of our experiments on the sulphur-lime treatment have pointed to the importance of bringing the mixture into close contact with the seed. While thinking over this it occurred to us to try the direct application of fungicides to the seed.

A quantity of smut-infested soil was secured and to make sure that it was thoroughly impregnated with smut spores a quantity of the juice of smutty onions was mixed with it. Five boxes, 12 inches square and 4 inches deep, were filled with this soil. One box was planted with onion seed which had been dipped in a 10 per ct. solution of potassium sulphide; one box with seed dipped in eau grison;[13] one box with seed wet with water and then rolled in sulphur and lime; one box with seed wet with thin glue and then rolled in sulphur and lime; and the remaining box with untreated seed for a check. A sixth box was filled with sterilized soil and sowed with untreated seed; 200 seeds were planted in each box.

The seeds, which were first wet with thin glue and then rolled in sulphur and lime, retained the sulphur and lime nicely and we had high hopes of the success of this treatment. But when the plants came up many were found to be affected with smut, and at the end of four weeks there was but one living plant in all five boxes of the smutty soil. They had all died with smut; while in the box of sterilized soil there was nearly a full stand of healthy plants.

Thus it appears that a coating of sulphur and lime on the seed alone is not sufficient; the fungicide must be where it will come in contact with the caulicle or radicle or perhaps both.

CONCLUSIONS AND RECOMMENDATIONS.

There seems to be no doubt that onion smut can be prevented to a considerable extent, but not wholly, by the application of sulphur and air-slaked lime in the drills at the time of sowing

[13] For the formula of eau grison see Lodeman, E. G. The Spraying of Plants, p. 147. MacMillan & Co., 1896.

the seed. What quantity of sulphur and lime it is best to use has not been definitely determined, but in our experiments excellent results have been obtained from the use of 100 pounds of sulphur and 50 pounds of lime (equal parts by measure) per acre. We recommend the use of this quantity until it has been shown by experiment that some other quantity gives better results.

There is no danger of harmful results from the accumulation of the sulphur in the soil provided it is not used in excessively large quantities. Broadcast applications of the sulphur and lime have little if any effect on smut; the application *must* be made in the drills.

The smuttier the land the better, proportionally, will be the returns from the sulphur-lime treatment. In general, we believe it will be found profitable to apply the treatment to any field on which it is impossible to obtain more than two-thirds of a full crop because of smut. With a perfect working machine for applying the mixture perhaps the treatment will be profitable where the loss from smut is even less than one-third of the crop. Without the use of a machine the treatment must be made by the somewhat laborious method of first opening the rows either with a seed drill or some sort of marker, then scattering the sulphur and lime in the open rows by hand, and finally running the seed drill over the rows a second time to sow the seed. Although involving considerable extra labor and a small money outlay for sulphur (about two dollars per acre) we are confident that the treatment is profitable, especially on very smutty land.

While the sulphur-lime treatment will undoubtedly give considerable relief and we advise its use, it should not be forgotten that smut may be *wholly* prevented by rearing the seedings in hotbeds and transplanting. We advise those onion growers who suffer heavy losses from smut to investigate the transplanting method. Surely there is some way of applying it profitably to the methods of onion growing practiced in Orange County; and if there is not it may be worth while to alter the methods and grow the large onions to which the transplanting method is especially

applicable. It should also be borne in mind that transplanting has the same effect as a rotation of crops in starving out smut.

The rotation of crops, too, is worthy of consideration. Surely the onion crop is not the only one that can be profitably grown on the "meadows" in Orange County. Such soil is admirably adapted to the growth of celery, and to other plants. It seems advisable for onion growers in that section to develop the culture of some other crops to be grown in rotation with onions.

THE STERILE FUNGUS RHIZOCTONIA AS A CAUSE OF PLANT DISEASES IN AMERICA.*

B. M. DUGGAR AND F. C. STEWART.

SUMMARY.

Rhizoctonia is a name given to certain sterile fungi occurring upon the subterranean parts of plants. Botanical literature contains numerous accounts of plant diseases in Europe caused by *Rhizoctonia;* but little has been written on such diseases in America.

Finding that *Rhizoctonia* is common on various cultivated plants in America the authors have undertaken an exhaustive study of the genus. The bulletin is a preliminary report. It contains accounts of the discovery of the fungus on about 30 species of cultivated plants in the United States.

Rhizoctonia is the cause of a destructive root-rot of the sugar beet, a destructive stem-rot of the carnation, a leaf-rot of greenhouse lettuce, a leaf-rot of ornamental asparagus and a root-rot of the carrot; and is of common occurrence on stems and tubers of the potato. It is a frequent cause of damping-off of various seedling plants, such as beet, carnation, celery, lettuce, cabbage, etc. It is also the suspected cause of disease in the bean, rhubarb, cotton, and some other plants. Further observations will probably show that many other plants are infested by it.

*Reprint of Bulletin No. 186.

How many distinct species of the fungus there are is unknown; but the number is probably much smaller than the number of host plants. This must be determined largely by cross-inoculation experiments. Such experiments have been in progress for two years, but the report on this part of the investigation, as well as on several other features, will be reserved for a future publication.

THE STERILE FUNGUS RHIZOCTONIA AS A CAUSE OF PLANT DISEASES IN AMERICA.

Being a Preliminary Report upon the Occurrence of Diseases of Plants in America Caused by Different Forms of the Sterile Fungus Rhizoctonia.

By B. M. Duggar, Cryptogamic Botanist, Cornell University Agl. Exp. Sta. and F. C. Stewart, Botanist, New York Agl. Exp. Sta.

INTRODUCTION.

Studies on a beet root-rot and a carnation stem-rot in 1898 first drew the writers' attention particularly to the fungus *Rhizoctonia* as a cause of various plant diseases in this country. It needed no extended search to ascertain that this fungus is much more commonly associated with diseases of certain greenhouse and field plants than our economic literature would suggest. During the three seasons that our attention has been directed to this matter, the occurrence of *Rhizoctonia* on some entirely new hosts has been observed, and also upon other hosts new to America. As a preliminary report, it now seems well to bring the subject to the attention of American mycologists. Our work is directed towards a monograph including all known species of this fungus; and it is hoped that these notes will enlist the support of other workers, and some contributions of material.

Besides a brief historical and morphological account, this bulletin concerns itself merely with the presentation of some notes upon the occurrence and destructiveness of American forms observed by the authors. We reserve for the final paper all details of special morphology and physiology of the forms, as well as general matters of taxonomic interest and a discussion of

European species. Nothing will at present be said of the limitations or identity of species. The latter is a matter which must be determined largely by cross inoculations, together with morphological studies. Inoculation experiments have been in progress for two years, but they are not yet in shape to be fully reported; hence a presentation of the results will be deferred.

Rhizoctonia is a form genus established to include certain sterile fungi occurring upon the roots of plants. The members of this genus, however, may be readily located by certain distinguishing characters of the mycelium. In pure culture, moreover, a very characteristic form of growth is to be found. The young hyphæ growing in diseased tissue or in pure culture show a distinctive manner of branching; but as this character is in general the same for all, a description of the beet fungus will suffice for this account. The young branches are inclined to the direction of growth of the parent branch at an angle more or less acute. And the former are somewhat narrowed or constricted where united with the latter, as in Fig. 1. At a distance of a few microns from these places of union, a septum is invariably formed. The young hyphæ are often strongly vacuolate; but later they usually become uniformly granular and more deeply colored. The branching also seems to have occurred more nearly at right angles to the main hypha, and the constriction at the place of union may not be so marked. (See Fig. 2.) On the beet root a short, tufted, or somewhat sporodochia-like growth of the mycelium may also occur. The hyphæ of these tufts are brown, closely septate, constricted at the septa, and often branching in an irregular or dichotomous fashion, as in Fig. 3. Such hyphæ may eventually break up into hyphal lengths of a single cell or several cells in extent. The individual parts then seem to function as conidia, and germinate within a few hours when placed in suitable conditions. So far as observed, germination is always by the protrusion of a tube through a septum. When several cells are connected, a germ tube from one cell may pass into and through its neighbor, as in Fig. 4, and thus peculiar appearances may result. Some of the cells of the hyphal chains seem

to be devoid of protoplasm, and from neighboring protoplasmic cells the germ tubes seem to pass into such empty cells as readily as directly into the nutrient solution. When the germ tube is from 10μ to 20μ in length, it is invariably narrowed towards the outlet from the parent cell, and a septum forms at a short distance from this outlet, as in Fig. 4. Large, irregular, sclerotial bodies are sometimes found upon the beet, but they are by no means of constant occurrence.

If a part of a diseased beet is placed in a moist chamber, a loose mycelial growth soon appears, and the threads may grow out to the extent of half an inch or so. From this it is an easy matter to obtain a pure culture by transferring some of this mycelium to acidulated agar in petri dishes. The fungus grows readily upon acidulated agar, while bacteria are for the most part excluded. The fungus may then be transferred to bean pods, or beet plugs, in test tubes, upon both of which media most forms of *Rhizoctonia* seem to grow well. In pure culture a loose mycelial growth first appears. This becomes brown in time. A short tufted growth may appear later; and usually there is also an effuse or crust-like sclerotial development. In culture the sclerotia are usually irregular in form and brown in color.

At this time it is not desired to enter into a discussion of the slightly different morphological characters which may distinguish the different forms of *Rhizoctonia*.

BRIEF NOTES UPON RHIZOCTONIA IN EUROPE.

(*Historical.*)

The root-destroying fungus *Rhizoctonia* was first discovered by De Candolle[1] in 1815. He named two species: *Rhizoctonia medicaginis*, occurring on *Medicago, Trifolium* and related hosts; and *R. crocorum*, a fungus destructive to crocus bulbs. Of the brief notes published upon other species of the fungus and other host plants until 1851, a comprehensive summary is given by the brothers Tulasne.[2] They believed that the several species then

[1] De Candolle—Mem. d. Mus. d'hist. nat., 1815.

[2] Tulasne, L. et C.—Fungi Hypogaei, pp. 188–195, 1851.

described were not to be regarded as distinct, and all were thrown together under the name *Rhizoctonia violacea*. In 1858 Kühn[1] discussed more at length certain forms of economic importance, and made known some new hosts among agricultural plants. Fuckel[2] reported a perithecial form, *Leptosphæria* (*Byssothecium*) *circinans* and also a pycnidial form of *R. medicaginis* D. C. The only claim for the relationship of these forms was based upon their association in nature.

In a similar way other fungi have been subsequently suggested as perfect stages of *Rhizoctonia*, but evidence of genetic relationship is constantly lacking.

Among forms more recently described may be mentioned an oak root-fungus discovered by Hartig.[3] It was found closely associated with the ascomycetous form *Rossellinia quercina*, so that the reported rhizoctonial stage was described under the latter name.

Scholtz[4] has described *Rhizoctonia strobi*, causing a disease of the Weymouth pine, and he was unable to establish any connection between the hyphæ of this *Rhizoctonia* and those of certain fruiting forms on plants killed by this disease.

Frank[5] has recently reported *R. violacea* as destructive to grape vines. A perfect form is reported which he names *Thelephora rhizoctoniæ*.

Rostrup has also described *Rhizoctonia fusca*, the cause of a disease of turnips in Sweden. Comes, Sorauer and Frank have also given full general accounts of the European rhizoctonial diseases in their works on plant dseases.

The list of European host plants now covers a very wide range. The following are the most important plants affected: alfalfa, asparagus, beet, carrot, various clovers, crocus, fennel,

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[1] Kühn, J.—Krankheiten der Kulturgewächse, Berlin, 1858.

[2] Fuckel.—Botan. Zeitung, 34, 1861 (p. 250).

[3] Hartig, R.—Untersuch. aus d. forstbotan. Institut zu München, 1888.

[4] Scholtz.—*Rhizoctonia strobi*, ein neuer Parasit der Weymouthskiefer. Verhandl. d. zoolog. botan. Ges. Wien, 47: 541-557, 1897.

[5] Frank, B.—Ein neuer Rebenschädiger in Rheinhessen [Ref. Centrbl. f. Bakt. Parasitenk. u. Infektionskr., 4, 781, Abth. II.]

geranium, oak, onion, pine, potato and turnip. In all of the above the fungus is primarily a root parasite, and it will be seen that it occurs upon fleshy, herbaceous and woody roots.

RHIZOCTONIA IN AMERICA.

(*Historical.*)

Neglecting for the present any such mentions of *Rhizoctonia* as have been made in "Lists of Fungi," or even brief technical descriptions of new forms, we find in American literature very little concerning *Rhizoctonia*. In 1891 Pammel[1] published some notes on beet diseases, and a beet root-rot was described which he considered due to *Rhizoctonia betæ* Kühn,[2] this fungus having been mentioned by Kühn, Eidam and others as an important beet disease in Germany.

In 1892 Atkinson[3] found in Alabama a sterile fungus causing a damping-off of cotton, also called "sore shin." Later he found and described a similar fungus in connection with the damping-off of various seedlings under glass at Ithaca.[4]

The above are the chief economic references to the occurrence of *Rhizoctonia* in America until the appearance of Bulletin 163[5] of the Cornell Experiment Station. In December, 1898, the writers presented a paper on *Rhizoctonia* to the Society for Plant Morphology and Physiology at its meeting in New York City. This paper, which was entitled "Different Types of Plant Diseases due to a Common *Rhizoctonia*," was published only in abstract.[6] During the past year Stone and Smith[7] have published an account of lettuce *Rhizoctonia* and some experiments on its

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[1] Pammel, L. H. Bulletin 15. Iowa Agl. Exp. Sta., 1891.

[2] Kühn, J.—l. c.

[3] Atkinson, Geo. F. Some Diseases of Cotton. Bulletin 41, Ala. Agl. Exp. Sta., 1892, pp. 30–39.

[4] Atkinson, Geo. F. Damping off. Bulletin 94, Cornell Univ. Agl. Exp. Sta., 1895, pp. 339–342.

[5] Duggar, B. M. Three Important Fungous Diseases of the Sugar Beet. (See pp. 339–352.)

[6] See Bot. Gaz., 27: 129.

[7] Stone, G. E., and Smith, R. E. The Rotting of Greenhouse Lettuce. Mass. Exp. Sta., Bul. 69.

treatment. In the succeeding pages we give our observations upon the occurrence of *Rhizoctonia* upon various plants in America.

ON THE BEAN.

(*Phaseolus vulgaris.*)

Early in August, 1900, we received a few complaints of the ravages of what appears to be an undescribed stem-rot disease of beans. A field of about twenty acres of red kidney beans near Geneva was considerably injured by the disease. The plants were affected as follows: At a distance of from one to two inches above the surface of the soil there was a place on the stem where the tissues were dead and discolored. Frequently, this occurred at the point where the plants commenced to branch. The dead part was dry-rotten clear to the pith, from one-half inch to one inch or more in length, and usually extended entirely around the stem. Being much weakened at the point of attack, it was a common thing for affected plants to be broken over by the wind. When this did not happen, the whole plant slowly dried up and died.

Although larvæ were occasionally found in the diseased stems, it was plain that the trouble was not due to any insect. In all stages of the disease the affected parts were constantly filled with a species of *Fusarium*, which at that time we suspected to be the principal cause of the disease. However, *Rhizoctonia* hyphæ were also present in a great many cases. Sometimes the medulla of dead plants were completely filled with *Rhizoctonia*, and occasionally it was found in early stages of the disease; but it was not constantly present in quantity. The crop preceding the beans was corn.

From Phelps we received bean plants affected with the same disease and some of them showed an abundance of *Rhizoctonia*. Mr. F. M. Rolfs[1] also reports having found *Rhizoctonia* on beans on Long Island.

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[1] Our thanks are due Mr. Rolfs who has made a great many field observations for us.

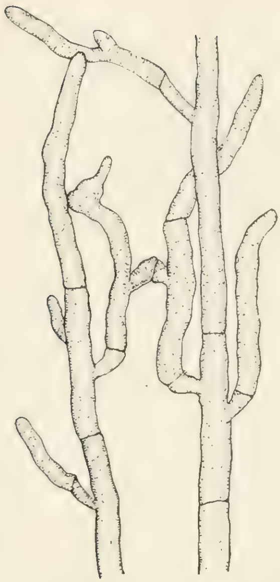

FIG. 1.—YOUNG HYPHAE OF THE RHIZOCTONIA.

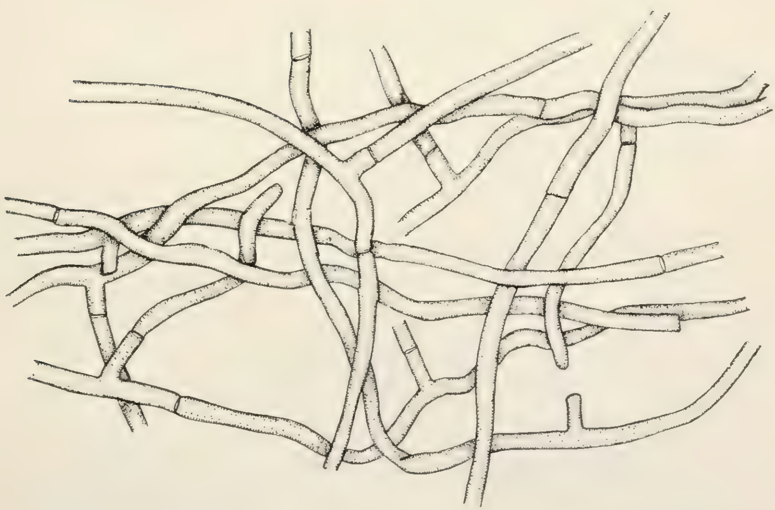

FIG. 2.—THE BROWN HYPHAE WHICH INVEST THE CRACKS ON DISEASED BEETS.

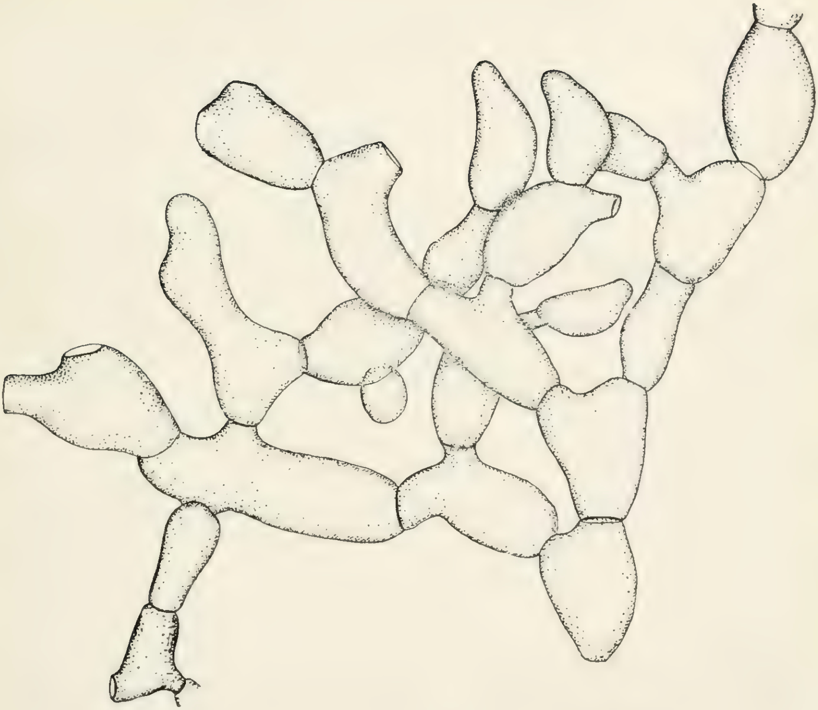

Fig. 3.—The Large, Closely Septate Hyphae which Make Up the Short Tufted Growth.

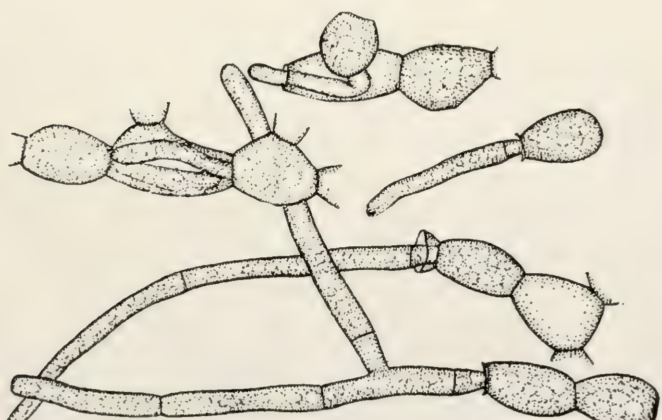

Fig. 4.—Germinating Cells of the Beet Root-Rot Fungus.

Later, pure cultures from the Geneva material proved capable of producing disease in carnation plants, so that the fungus is very likely pathogenic.

Moreover, on at least two occasions a *Rhizoctonia* has been found producing damping-off among seedling beans in the green house. The disease is characterized by an ulceration of the stem at the surface of the soil and later prostration and death of the seedlings.

ON THE BEET.

(*Beta vulgaris.*)

Our attention was first called to this disease by specimens of affected beets sent to us from Binghamton. A few days afterwards the disease was discovered as a beet trouble of considerable importance at Cattatonk, N. Y. This occurrence has been fully treated in Bulletin 163 of the Cornell Experiment Station, and at this time a summary of these notes will suffice. At Cattatonk a three-acre field was attacked so severely that fully one-third of the crop was lost. Diseased plants are usually found in scattered areas throughout the field; but the fungus undoubtedly passes readily from plant to plant in the row and it has a tendency to spread rapidly. Cold weather or dry conditions quickly retard the spread of the trouble, and it is much more abundant where the soil is moist or the surface drainage bad.

During hot weather the fungus secures a hold most readily at the bases of the leaves, perhaps because here there is moisture with the slightest rain or dew. Inoculation experiments also demonstrate that in these parts the disease "takes" well. The progress of the injury may be noted by the blackening of the leaf bases, and finally the wilting and prostration of the leaves themselves. The leaves do not, however, turn brown until after they have fallen. When the fungus has worked into the crown and root proper, a browning of those parts is evident, and finally deep cracks may appear, as shown in Plate VIII.

The brown mycelial threads of the fungus among the diseased leaf bases are evident to the unaided eye, and after the root has become affected, a considerable mycelial weft may be found in

the cracks and affected parts. A diseased beet sliced lengthwise and placed in a moist chamber yields in a day or two a luxuriant growth of the fungus.

This disease has since been reported to us in the central and the western parts of the State, but specimens were not seen. During the past season it was found again, in the month of August, at Flint and at Phelps, N. Y.; but in neither case was there any serious outbreak of the disease. Specimens collected at the former place showed a considerable development of sclerotia, which bodies had not been previously observed upon the beet. Furthermore, Mr. A. D. Selby has kindly told us that he has found this disease of beets in Ohio during the past autumn.

Inoculation experiments have been made in the field, and these all indicate beyond a doubt that this *Rhizoctonia* may readily produce beet root-rot when the conditions are favorable. Moist conditions are essential for the spread of the disease from plant to plant. Moreover, this fungus taken directly from diseased beets has the power of damping off lettuce and also beet seedlings.

A beet disease due to a species of *Rhizoctonia* has been known to botanists in Europe since 1855; and we are indebted to Professor Karl von Tubeuf, of Berlin, for material of that fungus. It is improbable that the American form is identical with the European. However, the disease found by Pammel[1] in Iowa may be the same as the one which we find in New York.

ON THE CABBAGE AND CAULIFLOWER.

(*Brassica oleracea.*)

Specimens of diseased cabbage seedings were received from Cairo, Ill., early in 1898. Among growers this disease is improperly called black rot. Sometimes the disease affects very young seedlings, and they are damped off by it, but it is more common after the plantlets have developed one or two true leaves. In

[1]Pammel, L. H. Loc. cit.

the latter, ulcerated areas at or below the surface of the soil often characterize the disease. Plants set in the field are not known to be affected. An examination of the Illinois material showed that a *Rhizoctonia* was constantly present in abundance, and undoubtedly the cause of the trouble. *Rhizoctonia* has also been found causing a disease of cauliflower seedlings at Geneva. The plants were ulcerated at the bases of the stems, sometimes the entire cortex having disappeared.

ON THE CARROT.

(*Daucus carota.*)

The hasty examination of a few carrot fields in August, 1900, resulted in the finding of a few plants affected with *Rhizoctonia.* In a field at Flint, N. Y., two specimens were found, and in another field near Phelps, N. Y., about a dozen more. In every case the plants were affected at the crown. The leaves were all dead, their bases being rotted off and thickly covered with *Rhizoctonia* hyphæ. About half an inch of the upper portion of the root was also rotten, but the disease showed no tendency to run down the root. In some of the specimens there were indications that the rot had been initiated by some larva boring into the crown of the plant.

Kühn[1] and others have reported the occurrence of *Rhizoctonia* on carrots in Germany, but we believe that up to the present time there is no record of the occurrence of such a disease in America.

ON THE CELERY.

(*Apium graveolens.*)

Our knowledge of the occurrence of *Rhizoctonia* on celery is confined to two cases in which it was the cause of a destructive damping off of celery seedlings. Both of these cases were observed in June, 1899. The first one occurred in one of the Station greenhouses at Geneva, and the other in a greenhouse at Poughkeepsie where celery plants were grown extensively. In

[1] Kühn, J. Krankheiten der Kulturgewächse, p. 224.

the latter instance the owner stated that he had had much trouble from damping off. In both of these cases *Rhizoctonia* was undoubtedly the sole cause of the trouble. We are informed that the damping off of celery seedlings is a common occurrence, but thus far we have had opportunity to investigate only the two cases above mentioned.

ON THE COTTON.

(*Gossypium herbaceum.*)

The *Rhizoctonia* which is the cause of "sore-shin" or damping off of cotton seedlings has not yet been secured by us; but Professor Atkinson has kindly put at our disposal drawings which he made while studying this fungus in Alabama. He first reported upon it under the caption "sore-shin" in Bulletin 41 of the Ala. Agl. Exp. Sta. In describing it, he says: "The diseased portion of the plant is just beneath the surface of the ground, and is characterized by a shrunken area of a dull reddish-brown color. * * * If the injury remains confined to the superficial tissues, the plant may, and frequently does, recover." The sterile fungus concerned with this disease was isolated, and inoculation experiments demonstrated that the fungus secured was the cause of the damping-off. The description of the fungus in the above mentioned bulletin and the drawings which we have, demonstrate beyond a doubt that the fungus is a form of *Rhizoctonia*.

ON THE LETTUCE.

(*Lactuca sativa.*)

Since 1896 we have repeatedly found lettuce seedlings damping off by a sterile fungus; but it was not until 1898 that it was particularly studied, or its affinities ascertained, and the fungus located as *Rhizoctonia*. Lettuce seedlings affected by this fungus have much the same appearance as seedlings affected by any damping-off fungus. At or near the surface of the ground the tissues become water-soaked in appearance, they are unable longer to support the plantlet, and it falls prostrate on the surface of the ground, the fungus soon invading all parts. This

fungus under favorable conditions may wilt down and destroy, within a day or two, whole boxes of lettuce seedlings. The disease is also readily induced by using pure cultures of the fungus for inoculation purposes.

What is apparently the same fungus has been found several times as a disease of maturer lettuce plants. After the presentation of a preliminary report upon rhizoctonial diseases before the Society for Plant Morphology and Physiology in New York, December, 1898, we received from Mr. R. E. Smith, Amherst, Mass., lettuce plants showing a severe rotting of the leaves. There was no doubt about the characters of the fungus, and we determined it for Mr. Smith as the *Rhizoctonia* of lettuce. From the characters of the parasitic material, as well as from pure cultures, we considered it identical with the damping-off fungus. The specimens received showed no rotting of the stem, the leaves being the seat of attack. On the older lower leaves the leaf blades alone are affected; but the more delicate inner leaves succumb entirely, blackening and decaying with the progress of the disease. Hyphæ[1] of the fungus occurred scantily over the leaf surface, and a short tufted growth might be found on the inner side of the petioles. These tufts were brownish-white or tawny in color and not so dark as the corresponding growth in culture.

During the past winter this fungus has also been found by Mr. Rolfs on greenhouse lettuce plants at Rochester.

Again, Atkinson[2] found a form of the sterile fungus studied by him in Alabama, causing damping-off of lettuce seedlings at Ithaca.

Occurring, then, in such widely separated regions it is very probable that it is a fungus very generally distributed.

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[1] Compare Stone, G. E., and Smith, R. E. The Rotting of Greenhouse Lettuce, Bulletin 69, Mass. Agl. Exp. Sta. (Hatch), p. 16–17, 1900.

[2] Atkinson, Geo. F. l. c.

ON THE POTATO.

(Solanum tuberosum.)

Although a *Rhizoctonia*[3] disease of potatoes has long been common in Europe, especially in Germany, where it is known under the names "Grind" and "Pockenkranheit," there is, so far as we are able to ascertain, no record of the occurrence of *Rhizoctonia* on the potato in America. Yet our observations indicate that potatoes in the United States may be quite generally infested by a species of *Rhizoctonia*, as the subsequent discussion will demonstrate.

The occurrence of this fungus upon potatoes was first brought to our attention by Messrs. F. A. Sirrine and F. M. Rolfs, who reported having found it on potato stems collected in the vicinity of Jamaica on Long Island. In the latter part of July the writers visited Long Island and examined several potato fields in the vicinity of Jamaica and Floral Park. A little *Rhizoctonia* was found on the potato stems in all of the fields examined, but it was impossible to determine whether the plants had suffered any injury from its presence. Unfortunately, the potato tops were nearly all dead at that time, the varieties grown in that locality being almost all early varieties. A few tubers were examined but nothing found. On this visit we also had the opportunity of examining some diseased potato stems collected on Staten Island by Miss Emma Sirrine, and found them infested with *Rhizoctonia*. A few days later Mr. Rolfs found it at Mattituck, Cutchogue and East Hampton, in the eastern part of Long Island. Here it occurred on late potatoes, and, in one instance at least, there was good evidence that it had killed a considerable number of plants. It was also found at Wading River. There has been much complaint about the premature dying of potatoes on Long Island the past season. What part *Rhizoctonia* played in this trouble is not certainly known, but probably it was not an important one. Later, the *Rhizoctonia* was found on potato stems in many fields about Geneva, Phelps, Lodi and Oaks Corners.

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[3] *Rhizoctonia solani* Kühn.

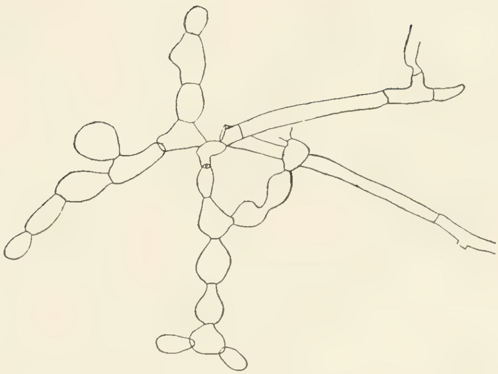

FIG. 7.—HYPHAE OF THE POTATO RHIZOCTONIA FROM DRAWING BY MR. SIRRINE.

FIG. 6.—RHIZOCTONIA SCLEROTIA ON A POTATO STEM. (NATURAL SIZE.)

FIG. 5.—A POTATO TUBER SHOWING THE SCLEROTIA OF THE RHIZOCTONIA. (7/8 NATURAL SIZE.)

On August 3 while peeling some scabby potatoes for potato agar we observed that some of the so called "deep scab" ulcers were filled with mycelium composed of rather coarse hyphæ. Microscopic examination showed the hyphæ to be those of *Rhizoctonia.* These tubers had been bought at a grocery in Geneva. Other tubers were then obtained from other groceries and also direct from potato fields in the vicinity of Geneva, and it was found that *Rhizoctonia* hyphæ are of frequent occurrence in scab ulcers.

The next advance made was the discovery of the *Rhizoctonia* sclerotia on the tubers and stems. On September 21 Mr. Rolfs found, in a potato field near Geneva, a tuber bearing a few sclerotia of *Rhizoctonia.* The following day the field was revisited and carefully searched. The crop had been harvested several days earlier, and in the interval rain had washed the dirt from such tubers as had been overlooked and also from the stems of the plants which were left in the field. This facilitated the search and we soon gathered about 30 tubers bearing sclerotia. See Fig. 5. Then we began looking for sclerotia on the stems and had little difficulty in collecting about 25 good specimens. One of these is shown in Fig. 6. Having once seen the sclerotia on the tubers it was easy to find them on almost every lot of tubers examined. We found them, oftentimes in great abundance, on tubers offered for sale at the groceries in Geneva, Poughkeepsie and Ithaca. A wagon load of potatoes offered for sale at Ithaca was so completely overrun with *Rhizoctonia* that it is doubtful if there could have been found in the entire load a single tuber which did not bear one or more sclerotia. Some of the tubers showed several hundred sclerotia each. These tubers were of the variety Rural New Yorker No. 2; and in other respects they were fine, being of large size and almost entirely free from scab and rot. They were grown at Slaterville, near Ithaca. A load of potatoes on the streets of Sayre, Penna., was examined and found to contain a considerable number of tubers bearing sclerotia. We have also seen the sclerotia on tubers grown at Mattituck and Cutchogue. Mr. A. D. Selby has

sent us from Wooster, Ohio, potato stems and tubers bearing *Rhizoctonia* sclerotia, showing that the fungus exists in that State. Specimens have also been received from Prof. J. F. Duggar, Auburn, Ala., Mr. F. M. Rolfs, Fort Collins, Colo., and Mrs. F. C. Stewart, who found it at Bassett, Iowa. In short, during the past season many observations on potatoes have been made in different parts of New York State, and *Rhizoctonia* has almost always been found in greater or less abundance. Moreover, it occurs in Alabama, Colorado, Iowa, Ohio, and Pennsylvania, and is probably very generally distributed. Recently the sclerotia have been found abundantly in the markets of Washington, D. C., on New York and Michigan potatoes, and also to a slight extent on one variety of potatoes grown in Maryland.

We have the following proof that the *Rhizoctonia* disease of potatoes existed at Ames, Iowa, as long ago as 1890. In the summer of 1890 Mr. F. A. Sirrine, at that time Assistant Botanist at the Iowa Experiment Station, investigated a potato disease which was doing serious damage on the Station farm. He found the subterranean parts of the affected plants covered with a certain fungus which he at once suspected of being the cause of the trouble. He was unable to identify the fungus. In the course of the investigation an important insect enemy of the potato, the potato-stalk weevil, was discovered[1] in connection with the disease, and as it appeared that this insect was responsible for at least the greater part of the trouble, attention centered upon it and the fungus was allowed to pass into oblivion. Fortunately, Mr. Sirrine made and preserved a camera-lucida pencil drawing of the fungus. This drawing shows that the fungus studied by Mr. Sirrine was undoubtedly a *Rhizoctonia*. We have inked in the drawing, without altering it in the least, and publish it herewith. See Fig. 7.

The *Rhizoctonia* attacks only the subterranean parts of the potato plant. The hyphæ occur in the medulla, where they are for the most part very slightly, if at all, colored, and on the outside of the stem and on the roots, where they are often light

[1]See Iowa Exp. Sta. Bull. 11: 490.

PLATE VIII.—A LATE STAGE OF RHIZOCTONIA BEET-ROT, SHOWING THE CRACKING AND ROTTING OF THE ROOT.

PLATE IX.—A CARNATION AFFECTED WITH RHIZOCTONIA STEM-ROT.

brown in color. When the hyphæ occur in scab ulcers, those near the surface are brown, while the deeper-lying ones are colorless. The sclerotia on the stems and those on the tubers are essentially the same. They are irregular in outline and vary in size from a mere speck to the size of half a pea or even larger. When dry they are dirt colored, and it is difficult to distinguish them from particles of soil adhering to the tubers. This probably accounts for their having been so generally overlooked. But when wet they become dark brown and very conspicuous, particularly on the light skinned varieties of potatoes. In spite of vigorous washing, sufficient to thoroughly remove the soil from the tubers, the sclerotia remain firmly attached. Two housekeepers whose attention we have called to the matter assure us that they have long observed that when potatoes are prepared for baking there are often found dark brown irregular bodies which are exceedingly difficult to remove by washing. It is necessary to use a scrubbing brush to get rid of them. We suspect that these sclerotia are well known to many of the more observant housekeepers.

The amount of damage done by the *Rhizoctonia* when it attacks the subterranean stem and roots of the potato is as yet undetermined, but that the fungus is, in some cases at least, a parasite there is little doubt. Where it occurs on the tubers, all of our numerous observations go to show that it is not injurious to them. While the *Rhizoctonia* hyphæ may be abundant in scab ulcers there is no evidence that they have anything to do with the formation of the ulcers. The sclerotia are usually seated on the uninjured skin of the tuber. A tuber may bear hundreds of sclerotia and yet be absolutely sound. In this respect our *Rhizoctonia* appears to differ from the European potato *Rhizoctonia*. Some writers report that the latter is a common cause of potato rot. In other respects the two forms are strikingly similar. We are under obligations to Prof. Dr. Paul Sorauer of Berlin for excellent fresh specimens of the European *Rhizoctonia solani*, from which cultures for inoculation work have been obtained.

ON THE RADISH.

(*Raphanus sativus.*)

In the winter of 1898 diseased radish plants of marketable size were received from Saratoga, N. Y. The disease consisted of a soft rot of the crown, or of large ulcerations in this region. As a rule, the leaves were unaffected until a considerable portion of the root had decayed. It was reported, however, that plants in all stages of growth were affected and killed. It proved to be a trouble of considerable importance with forced radishes, and nearly half of the crop was lost from this disease. It spread rapidly from plant to plant in the row, and from well-established centers of infection. When the material was received, the tissues surrounding diseased areas were infested with hyphæ of a *Rhizoctonia.* These hyphæ were also very abundant superficially, growth being induced, perhaps, by the moist conditions under which the plants had been kept. A culture of the fungus was secured, and with half-grown radishes kept under moist conditions the disease was induced; but only a few plants were involved in this experiment. Unfortunately, this culture was afterwards lost, and it has not since been observed as a disease of mature plants. Nevertheless, *Rhizoctonia* has been found occasionally in the greenhouse as a radish damping-off fungus of slight importance.

ON THE RHUBARB.

(*Rheum rhaponticum.*)

For several years a peculiar disease of rhubarb has been observed on Long Island; but until the past season no satisfactory cause of the trouble was evident. During July several rhubarb fields were visited in the vicinity of Jamaica, and in many of these the leaves were dying rapidly, the plants being in an unthrifty condition. There was little or no injury due to the leaf-spot fungus *Phyllosticta rhei,* and the trouble was evidently of other origin. Affected leaves became dried and shrunken in appearance, and soon fell to the ground. Where a field was badly affected, the majority of hills would show the

trouble to the extent of at least a leaf or two. In several instances, apparently from one-fourth to three-fourths of the leaves were already dead. Fields thus affected showed noticeable injury even from a considerable distance.

Close by an affected field, or sometimes even contiguous to it, might be found a field showing the trouble only to a very slight degree. This may have been due to a longer culture of the rhubarb upon one than upon the other area.

An affected leaf breaks off readily just beneath the surface of the ground, and it was found that dead or prostrate leaves had rotted off in this region. The general appearance reminded one strongly of the effect of *Rhizoctonia* upon beets. There was very little superficial mycelium visible to the unaided eye. Microscopic examination showed hyphæ of a *Rhizoctonia* both superficially, and also immediately under the surface where the leaves were rotting. No other fungus was at any time found abundantly associated with the disease, and the *Rhizoctonia* was quite constantly present.

ON ORNAMENTAL ASPARAGUS.

(*Asparagus sprengeri.*)

In May, 1900, a florist on Long Island called our attention to dead patches in a large bench of *Asparagus sprengeri* in one of his greenhouses. The plants were dead and the leaves, which were gray and dry, had a tendency to cling to each other. Closer observation showed that the leaves were bound together with brown threads which proved to be *Rhizoctonia* hyphæ. The disease seemed to be unimportant, being confined to small areas where the foliage was kept unduly wet by the dripping of water from the glass above. The roots of the affected plants were not examined. Pure cultures of the fungus have been secured.

Knowing that, in Europe, the garden asparagus, *A. officinalis*, is affected by a *Rhizoctonia*[1] root-rot we visited Mattituck, Long Island, for the purpose of searching for the *Rhizoctonia* in the extensive asparagus fields of that locality. Owing to unfavor-

[1] *Rhizoctonia violacea* Tul.

able weather the search was not as thorough as it should have been, but we failed to find any indications of the presence of *Rhizoctonia* on asparagus roots.

For excellent specimens of the European fungus on the last named host we are also indebted to Prof Sorauer.

ON THE CHINA ASTER.

(*Callistephus hortensis.*)

In the summer of 1899, Mr. Murrill received from a correspondent specimens of diseased China asters. From his notes we find that the plants presented a wilted appearance, but he observed no fungus either upon branch or leaf. As described by the gardener, the disease might well have been due to a *Rhizoctonia*. An examination of a specimen preserved showed that the lower part of the stem was considerably permeated with hyphæ of a *Rhizoctonia*. The fungous threads were also present superficially, and small crust-like sclerotia had formed upon the stem. There is as yet no further evidence that the fungus found was the cause of the disease. A pure culture of the *Rhizoctonia* was, however, secured, and the fungus will be tested.

During the present season, China asters collected by Mr. Rolfs at Border City, N. Y., also showed a *Rhizoctonia* associated with as aster stem disease. Particular stress cannot be put upon this matter until inoculation experiments are made, for there seems to be at least one other stem disease of asters due to another fungus.

ON THE CARNATION.

(*Dianthus caryophyllus.*)

The carnation is subject to a very destructive *Rhizoctonia* disease known to florists by the name of stem-rot. Affected plants wilt suddenly, take on a gray green color, and are soon dead and dry. The seat of the trouble is found to be in the stem at or just below the surface of the soil. The cortex on this portion of the stem is soft-rotten and separates readily from the wood. The medulla is rotten and both medulla and cortex are filled with the hyphæ of *Rhizoctonia*. Not infrequently large, brown,

irregular sclerotia are found attached to the subterranean portion of the stem and occasionally to the roots.

That *Rhizoctonia* is the cause of this carnation stem-rot has been proven conclusively by inoculation experiments with pure cultures repeated many times. Plate IX is from a photograph of a carnation plant killed by artificial inoculation with a pure culture of *Rhizoctonia.* It presents the symptoms typical of the *Rhizoctonia* stem-rot disease.

This stem-rot[1] is one of the most troublesome of the carnation diseases and probably occurs throughout the whole United States wherever the carnation is grown. Frequently entire houses of mature plants are destroyed by it. During the past autumn it appears to have been unusually prevalent. It attacks plants of all ages both in the field and in the greenhouse, and is one of the principal causes of the damping off of carnation cuttings. In greenhouse benches it spreads slowly through the soil from one plant to another; but according to our experiments never through the air, as from one bench to another. Its principal mode of dissemination is by means of affected plants and cuttings.

ON THE SWEET WILLIAM.

(*Dianthus barbatus.*)

Since *Rhizoctonia* is an active parasite on the carnation, it is to be expected that it attacks the closely related *Dianthus barbatus*, and such appears to be actually the case.

November 5, 1900, we had the privilege of examining a badly diseased plat of about 1,600 plants of *Dianthus barbatus* at Queens, Long Island. In the course of the season about 90 per ct. of these plants had died from a sort of stem-rot. Several of the dead plants were not completely dry at the time of our visit, so it was possible to get some idea of the nature of the disease and its cause. The symptoms were strikingly like those

[1] There is a somewhat similar and destructive *Fusarium* stem-rot of carnations. See Sturgis, W. C., Twenty-first Ann. Rep. Conn. Agr. Exp. Sta. (1897), 175–181; Prillieux et Delacroix, Compt. Rend. de l'Acad. Science, 129: 744–745; and Stewart, F. C., Bot. Gaz., 72: 129–130.

of the *Rhizoctonia* stem-rot of carnations. The leaves had a sickly, yellowish color and were perfectly limp. The main stem and its numerous branches were soft-rotten at the surface of the soil, so that when an attempt was made to pull an affected plant it broke off readily at that point, leaving the main stem in the ground and many separate branches in the hand. The basal portions of these branches were disintegrated, the wood elements being separated from each other as if the tissues had been macerated.

The rotting stems contained an abundance of *Rhizoctonia*, various other fungi and nematodes, which latter are of course expected to occur in tissue so much decayed. Although not yet tested by inoculation experiments, the indications are that *Rhizoctonia* killed the plants.

It is of interest to note that the plat in which the plants were growing had been planted with carnations in the season of 1899, and they are said to have suffered considerably from *Rhizoctonia* stem-rot.

ON *Coreopsis lanceolata.*

Next to the plat of Sweet Williams above mentioned there were two rows of *Coreopsis lanceolata* which, so the owner informed us, had been considerably diseased during the summer. Only a few of the plants were killed outright, but from many of them the lower leaves had rotted away. The rot seems to start in the base of the petiole where it comes in contact with the soil. The decaying leaves were overrun with *Rhizoctonia*, but what relation the fungus bore to the disease can only be conjectured.

ON THE VIOLET.

(*Viola odorata.*)

In October, 1899, two diseased violet plants were sent to us from Little Falls, N. Y. Both of these plants showed *Rhizoctonia*, leading to the suspicion that violets also are attacked by this fungus; but when a personal examination of the afflicted violet house was made, not another case of *Rhizoctonia* could be found. The trouble was caused by *Glœosporium violæ.* More-

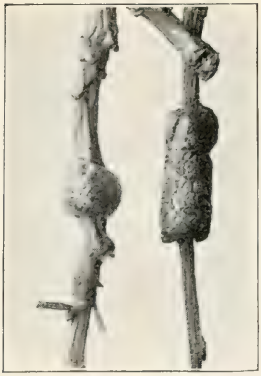

FIG. 8.—EGG MASSES;
NATURAL SIZE.

FIG. 9.—CELLS ENCLOSING BEETLES ON TRUNK OF
YOUNG PLUM TREE. NEGATIVE BY P. J. PARROTT.

over, the two Rhizoctonia-infested plants were potted and placed in one of the Station greenhouses where they thrived and never after showed any ill effects from the presence of the *Rhizoctonia*.

About a year after this experience, interest in the violet *Rhizoctonia* was revived by Mr. Rolfs' discovery of a case of destructive violet stem-rot in a greenhouse at Geneva. Here the affected plants were abundantly infested by *Rhizoctonia*. At about the same time we found it on violets at Floral Park. The plants were in small pots. Some of them had stem-rot[1], while on others only the bases of the petioles were rotten. The rotten parts frequently contained *Rhizoctonia*.

Thus it appears that *Rhizoctonia* occurs not infrequently on violets, but whether as a parasite or only as a saprophyte can not now be stated.

OTHER HOSTS.

In addition to the occurrence of *Rhizoctonia* as an apparent cause of diseases of the host plants already mentioned, there are several other plants upon which we have occasionally found this fungus. For the sake of brevity, we will condense the observations upon these, and bring them together under a single heading, deferring their more extended discussion until further observations and studies have been made upon them.

Rhizoctonia has been found on the roots and trunk of a dead cherry tree from Wright's Corners; as a damping-off disease of white pine and cucumber seedings; on damped off cuttings of begonia, coleus, verbena, hydrangea, hardy candytuft, and mammoth sage at Floral Park, N. Y.; on mature plants of phlox and pyrethrum at Floral Park; and on young plants of snap dragon at Geneva. Mr. Rolfs has observed it on the raspberry, lamb's quarters (*Chenopodium album*), tumble weed (*Amarantus albus*), pigweed (*Amarantus retroflexus*), and on decaying squash stems at Geneva.

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[1] Violet stem-rot is a complex disease not well understood. The fungus *Thielaria basicola* Zopf is generally accepted as being the cause of it. See Thaxter, R., Fifteenth Ann. Rep. Conn. Agr. Exp. Sta. (1891): 166–167.

PARASITISM OF THE FUNGUS.

In many cases *Rhizoctonia* is truly parasitic, and there can be no question about its being the cause of the diseases with which it is associated. The diseases of beet, carnation, lettuce, and some others with which we have experimented may be readily induced by merely placing in contact with the plant pure cultures of the fungus; and in time infection will result, provided there is sufficient moisture. Infection results more readily with the carnation by direct insertion of bits of the fungus into the plant. In other cases where the fungus is associated with disease, we have as yet no proof that *Rhizoctonia* is the chief or even partial cause of the trouble. It may sometimes be associated with other fungi, perhaps *Fusarium*. Atkinson[1] has indicated that the sterile damping-off fungus of cotton may perhaps have a part to play in the *Fusarium* disease of cotton, at least in initiating the disease.

In spite of the fact that *Rhizoctonia* is at times an effective parasite, the fungus is probably capable of protracted existence upon decaying organic matter in the soil. In this way it may be able to propagate itself, and to spread from plant to plant in the soil even when culture or other means fail to disseminate it. In fact, it seems to be of very general occurrence in the soil, and is likely to be quite commonly found in propagating beds as a cause of damping-off among cuttings and seedlings. From our experience thus far, we venture to predict that few forms of this fungus will be found very selective as to host, and one may well search for it upon the common weeds. The occurrence of this fungus as a disease producing organism is largely dependent upon the conditions, and when by excess of moisture or of heat the plant is placed at a disadvantage, or the fungus favored, the disease is likely to occur.

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[1] Atkinson, Geo. F.: Some Diseases of Cotton. Ala. Agr. Exp. Sta., Bulletin 41, p. 28.

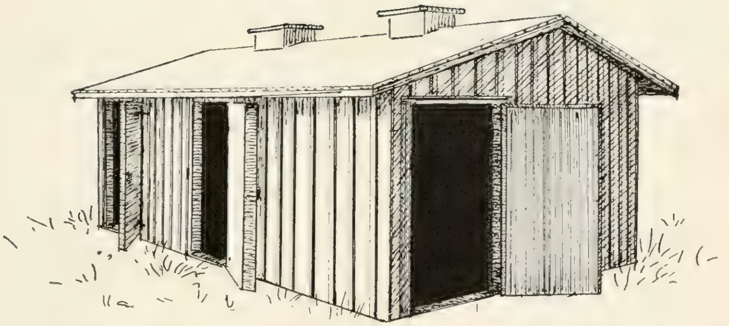

FIG. 10
FUMIGATING HOUSE SHOWING DOORS.

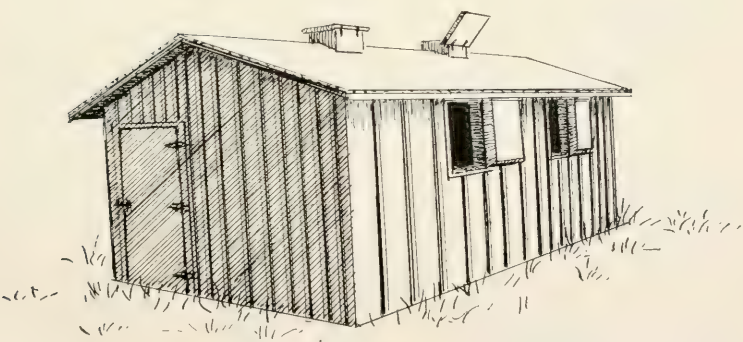

FIG. 11
FUMIGATING HOUSE SHOWING VENTILATORS.

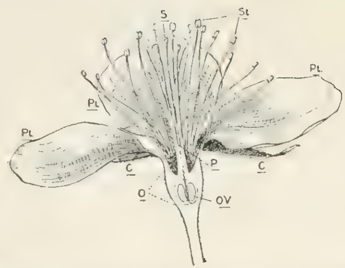

FIG. 12.—SECTION OF AN APPLE BLOSSOM SHOWING THE PARTS OF THE FLOWER. C, CALYX; PT, PETALS; ST, STAMENS; S, STIGMATIC SURFACE; O, OVARY; OV, OVULES.

FIG. 14.—POLLEN GRAINS OF AMARYLLIS JOHNSONI BEFORE GERMINATING.

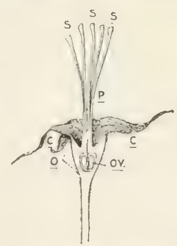

FIG. 13.—SECTION OF AN APPLE BLOSSOM WITH PETALS AND STAMENS REMOVED, LEAVING THE CALYX AND PISTIL. S, STIGMATIC SURFACE; O, OVARY; OV, OVULES.

FIG. 15.—POLLEN GRAINS OF AMARYLLIS JOHNSONI AFTER GERMINATION, SHOWING THE BEGINNING OF THE POLLEN TUBES.

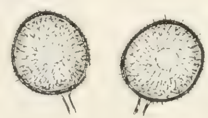

FIG. 16.—SPORES OF THE CARNATION RUST FUNGUS UROMYCES CARYOPHYLLINUS BEFORE GERMINATING.

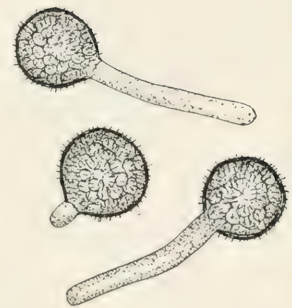

FIG. 17.—SPORES OF THE CARNATION RUST FUNGUS AFTER GERMINATION SHOWING THE BEGINNING OF THE GERM TUBES.

MEANS OF PREVENTION.

Little can be said at present concerning special means of prevention to be adopted for *Rhizoctonia* diseases. Plants growing under the most favorable conditions of moisture, temperature, and nutrition will probably show marked resistance to the attacks of such diseases, so that good sanitary conditions are of the first importance. An excess of moisture and the presence of freshly decaying plant products in the soil will unquestionably favor the disease. Particularly in the propagating and forcing benches is a frequent change of soil advisable. The fungus grows well upon acid media, and liming of the soil is therefore well; but this of itself is not thoroughly effective. If the fungus should become a serious pest in greenhouses, it may sometimes prove practicable to sterilize the soil with steam or with hot water.

SPRAYING FOR ASPARAGUS RUST.*

F. A. Sirrine.

SUMMARY.

All three stages of asparagus rust appear in this State. More than one stage can occur in the same rift or sorus.

Cutting and burning early in the fall to destroy the rust is injurious to the asparagus plants and is not recommended.

Thus far, in this State, no variety of asparagus has entirely withstood the attacks of the rust.

In 1898–1899 a gain of 69.5 per ct. in yield, equivalent to a financial gain of 94 per ct., was obtained by spraying; and in 1899–1900, under unfavorable conditions, a gain of 47.8 per ct. in yield or 44.5 per ct. in value. In no case did injury to the asparagus result from the use of resin-Bordeaux mixture.

A specially-constructed power sprayer was used to advantage in our work. This sprayer met all the requirements of an ideal machine, did the work more thoroughly and rapidly than could be done by hand, and also saved materials. It is not patented. Probably such a machine cannot be built for much less than $200. It is recommended that those who grow less than five acres undertake the building of such machines only in coöperation with others.

I. TESTS WITH RESIN-BORDEAUX MIXTURE.

INTRODUCTION.

Asparagus rust, *Puccinia asparagi* DC., has been more or less prevalent in this State during the past five years. Each year it

*Reprint of Bulletin No. 188.

has reduced the vitality of the plants, until the growing of asparagus in the market garden section around New York City has been practically abandoned. In sections like the east end of Long Island and Oneida and Madison Counties, where the canning factories take the larger portion of the crop, the growers are tenaciously retaining their beds although harvesting a lighter crop each year. The records of the Hudson Canning Company, Mattituck, N. Y., show that the average yield per acre for seasons prior to the outbreak of the asparagus rust varied between 1,500 and 2,500 bunches, while during 1899 and 1900 the average yield varied from 800 to 750 bunches per acre.

Some growers, however, are increasing their acreage, hoping that the rust will not be as bad in the future; that some variety will prove rust-proof; or that some other means of controlling the disease will be found. That the first two of these methods of relief are possible has been the opinion of several eminent pathologists; but thus far no such conditions have been reached. The rust, instead of abating, has been rapidly increasing in destructiveness; and no strictly rust-proof varieties have, as yet, been found. It is true that in some sections the Palmetto variety has been reported as being partially rust-proof; but it has not proven itself so under the conditions found in this State. In fact, it was one of the first varieties to be injured by the "cluster cup" stage in 1900. Even the Argenteuil, which is being put forward at present as rust proof, succumbed to the attacks of the rust during the past season. Whether it was as badly injured as some other varieties cannot be said, as it was not observed growing under field conditions.

In addition to resistant varieties, the following have been advocated as means of controlling the rust: Methods of cultivation and fertilization, burning, and even planting on heavy soils. Spraying has also been suggested; but for reasons given further on, most writers on asparagus rust have held out but little hope along this line.

The persistence of asparagus rust, with the evident ruining of the canning industry, if not of the culture of asparagus as a

money crop, by its attacks, not only in this State but also in other sections of this country, convinced us that it was necessary to determine definitely whether there could not be found some method or combination of methods by which this trouble can be controlled. It was also desirable to determine whether such methods could be put to practical use by the growers of asparagus. Some practical results have already been obtained and, as delay means additional loss each year to growers, the following preliminary report on the work is given.

HISTORY AND DISTRIBUTION OF THE RUST.

Asparagus rust has been known in Europe for nearly one hundred years, although English writers on asparagus culture do not mention its occurrence in that country until about 1876. Barnes and Robinson[1] state that its attacks on the part above ground have an unfavorable effect on the roots, checking their development. This causes a material reduction of the yield the succeeding spring owing to the premature ripening of many of the plants. Although the above writers were not positive regarding the nature of the disease, they were sure of its dangerous character and recommended that growers be careful to prevent its spread or its importation into districts that were free from it.

Although asparagus growers on Long Island and in the vicinity of Cape Cod believe they saw the effects of the asparagus rust in their fiel as early as 1895, it was practically unknown in this country until 1896. In that year Dr. Halsted[2] announced the occurrence of an outbreak of the asparagus rust in New Jersey. This announcement led to the discovery that the disease was already established in the asparagus fields of Delaware, Long Island and New England. Since 1896 it has been very destructive in these localities and has spread south into the Carolinas and west to Kansas, Iowa and Wisconsin.

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[1] Asparagus Culture, p. 22.

[2] Halsted, B. D. An Outbreak of Asparagus Rust. N. J. Agr. Exp. Stas., Circular, Sept. 18, 1896.

How and when the rust was introduced into this country is not known. It is possible that it was imported from Europe on plants or with a seed[3] a number of years prior to its discovery and, like the gipsy moth, required several years to become well enough established to be noticed. Although it is not known for how long a period the spores of the rust can withstand the drying effect of the wind, there is little doubt that the latter is one of the principal agents in distributing the rust over the country. It has certainly spread over a larger extent of territory during the past few years than would have been possible through distribution of the spores on asparagus plants and seeds.

DESCRIPTION.

Asparagus rust has been frequently described during the past few years; and its wide distribution makes it a well-known disease; yet it is deemed best to repeat briefly some of its characteristics as a basis for clear understanding of the experimental work herein reported.

It is a parasitic plant, or fungus, growing within the asparagus and absorbing the juices which should go to build up the tissues of the latter. The portion of the rust plant which we see and which gives it its name, is simply the spores, or seeds, of the fungus. These are formed beneath the epidermis, or bark, of the asparagus plant, causing this epidermis to lift and form pustules which, in two stages, produce slits or rifts. All are called sori. (See Plates X and XI, Figs. 1.)

The rust has three rather distinct stages or forms of growth. All three can occur on the same plant and frequently more than one form occurs at the same time.

Æcidial stage.—The first form, known as the æcidial or "cluster-cup" stage (see Plate X, Fig. 1), and sometimes called the "spring form" of the rust, is not usually distinguished from the second stage by growers of asparagus. It makes its appearance

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[3] P. H. Rolfs has reported finding the rust spores adhering to the asparagus seed. S. C. Agr. Exp. Sta. Rept. 1899, p. 17.

upon seedling beds and old neglected beds, as well as upon volunteer asparagus, on Long Island about the first of June. In the above section where ridging is practiced this stage is rarely seen on the cutting beds, but as seeding beds and neglected beds are always plentiful there is an abundance of the spring form.

In this first stage the spores are formed in cup-shaped pustules. These pustules or cups are grouped in clusters; hence the name of "cluster-cup." Examination with a lens shows that the cups are often of two kinds, associated together. Those of one form are called spermogonia, while the others, in which the spores are borne in bead-like chains, are called æcidia (see Plate X, Fig. 2, *a* and *b*). These cups are frequently arranged in oval and spindle-shaped groups upon the stem as shown in Fig. 1, Plate X, but nearly the same shapes are assumed by the other stages of the rust, hence this cannot be given as a definite characteristic. The cups never show as rifts or slits as do the later stages. At first they are greenish-yellow in color, but as they mature they change to an orange-yellow. Sometimes the cluster of cups shows only watery pustules; these are the spermogonia. In June, 1900, this stage was more prevalent on Palmetto seedling beds than on any other variety.

Uredo stage.—The second form, commonly called the "summer" stage and "red-rust" stage, is the one usually first noticed by growers. It is in this stage of growth that the rust increases and spreads most rapidly, and apparently does the greatest amount of damage. In this form the epidermis, or skin, of the asparagus appears to be covered with slits and rifts from which red granules or spores are exuding. These rifts are often grouped in oval and elliptical clusters on the stems, as in the first stage; but, instead of being cup-shaped pustules, they always occur as slits in the bark. It is this stage that gives the asparagus fields their peculiar brown color in such a short interval of time, and coats machinery and workmen with a red dust. The spores are one-celled, smooth, rather thin-walled and of a reddish-brown color (see Fig. 3, *u*, Plate XI).

Teleutospore stage.—The last stage is frequently called the "black" rust and "winter" stage. To the unaided eye there is no difference except in color, between this and the second stage. Close examination will show that the rifts are filled with dark brown spores which do not rub off and scatter as easily as the red rust spores. These winter spores are two-celled, are larger, and have thicker cell walls than those of the red rust (see Fig. 3, *t*, Plate XI). They are always formed whenever the vitality of the asparagus plant is reduced or its growth checked, no matter what the season of the year, whether early June or late October. According to Dr. Halsted[1] all three stages can occur at once on the same plant. It is supposed that these spores do not germinate until the following spring, at which time, if they succeed in getting a foothold on a young asparagus plant, they soon produce the first stage.

It is not known that it is absolutely necessary for the rust to pass through the three different forms named each year, or through any two of them. The last two forms may occur in the same rift or sorus, being produced by the same vegetative portion, or mycelial thread, of the fungus (see Fig. 2, Plate XI); possibly all the forms may be produced in the same way. All three forms certainly occur in this State: the first is found principally during the month of June; the second occurs during the latter part of June, and throughout the months of July, August, September and October; the third follows the second as soon as the asparagus commences to lose its vitality or begins to mature.

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[1] Bul. Torrey Bot. Club, 24: 509, 1897.

EXPLANATION OF PLATES FOR ASPARAGUS RUST.

PLATE X. FIG. 1.—*Æcidial or "cluster-cup" stage of* Puccinia asparagi *showing sori made up of clusters of cup-shaped pustules. Magnified 3 diameters.*

FIG. 2.—*Cross section of one of the sori of Fig. 1, showing* (*a*) *spermogonium,* (*bb*) *æcidial cups; one broken, with spores escaping, also one not broken open. Magnified 25 diameters.*

PLATE XI. FIG. 1.—*Uredo, or "red-rust," stage of asparagus rust showing form of sori, or rifts in the bark of the asparagus stem. Magnified 2 diameters.*

FIG. 2.—*Cross section of one of the sori shown in Fig. 1,* (*u*) *uredospores,* (*t*) *teleutospores. Magnified 75 diameters.*

FIG. 3.—*Uredospores and teleutospores. Magnified 75 diameters.*

PLATE XII. *General view of asparagus field sprayed fall of 1898, showing sprayed belt on the right. Taken Sept. 27, 1898.*

PLATE XIII. *Nearer view of field shown in Plate XII.*

PLATE XIV. *View of field sprayed 1899 and 1900, showing alternate rows sprayed. Taken Sept. 15, 1900.*

PLATE XV. *Field shown in Plate XIV, looking across rows.*

Fig. 1.

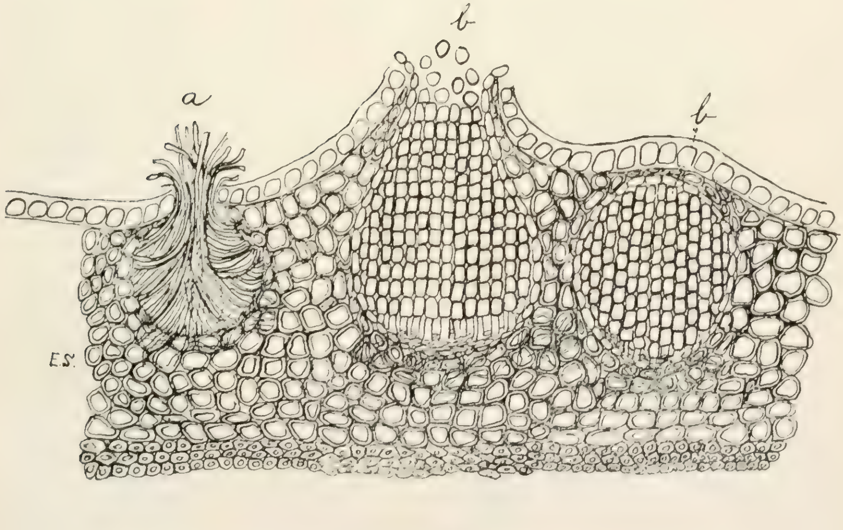
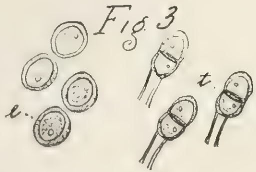


Fig. 2.

Plate X.—Gross and Microscopic Characteristics of Cluster-Cup Stage of Asparagus Rust.

FIG. 1.



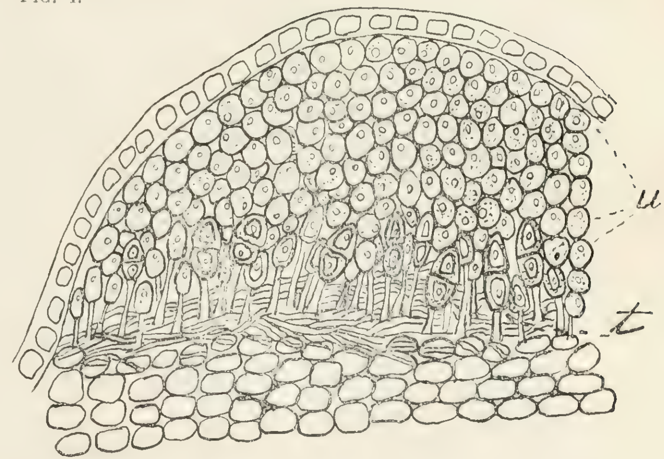


Fig. 2.

PLATE XI.—GROSS AND MICROSCOPIC CHARACTERISTICS OF SUMMER AND WINTER STAGES OF ASPARAGUS RUST.

PLATE XII.—UNSPRAYED AND SPRAYED ASPARAGUS.
(Taken Sept. 27, 1898.)

Plate XIII.—Unsprayed and Sprayed Asparagus.
(Nearer view of field in Plate XII.)

Plate XIV.—Alternate Rows of Asparagus Sprayed.
(Taken Sept. 15, 1900.)

Plate XV.—Alternate Rows of Asparagus Sprayed.
(Same field as in Plate XIV, looking across rows.)

METHODS OF CONTROLLING.

BURNING.

One of the first methods suggested by writers for checking the spread of asparagus rust was burning the affected brush. In fact this has been the principal method recommended by European writers such as Zimmerman,[5], Frank[6] and Abbey[7]. At first Dr. Halsted[8] recommended the same treatment. Drs. Sturgis[9] and Stone[10] followed Dr. Halsted's advice as did also Messrs. Jones and Orton.[11] In a later published work[12] Dr. Halsted says: "At best, with these precautions, many of the spores will get scattered upon the soil." Mr. Kinney[13], of Rhode Island, questioned the advisability of burning the brush in late summer; and later Messrs. Stone and Smith[14] took a similar view of burning, stating that they had only recommended burning the infected plants late in the fall when they were thoroughly dead and dried out; and that they had never seen the slightest benefit from burning the infected tops, while cases had been brought to their attention in which actual injury had resulted from cutting the tops and burning them in August. Following all the above suggestions Dr. Pammel[15] in a recent bulletin recommends burning as undoubtedly the best method of preventing the rust.

There is no doubt that in some sections the above measure has been abused. A few agricultural papers have recommended cutting and burning the beds as soon as the rust is observed. As a result some growers have followed the latter method with more harm than benefit to their crops. In 1899 this was tested on two

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[5] Atlas Pflanzen Krankheiten.

[6] Die Krankheiten der Pflanzen, p. 460. Breslau: 1880.

[7] Asparagus Diseases. *Jour. of Hort.*, 1895, pp. 452–453, London.

[8] *Garden and Forest*, 9: 395, 1896.

[9] Conn. Agr. Exp. Sta. Rept., 1896, p. 281.

[10] Hatch (Mass.) Agr. Exp. Sta. Repts., 1896, p. 73; 1897, pp. 59–60.

[11] Vt. Agr. Exp. Sta. Rept., 1898, p. 201.

[12] N. J. Agr. Exp. Sta. Bul. 129, p. 15.

[13] *Rural New Yorker*, 56: 658, Oct. 9, 1897.

[14] Hatch (Mass.) Agr. Exp. Sta. Bul. 61, pp. 14–15, 1899.

[15] Iowa Agr. Exp. Sta. Bul. 53, p. 66, 1900.

acres of Columbian White asparagus at Mattituck, New York. On August 14, every spear of the asparagus was cut and removed from the field, by the owner. Two weeks later a fairly good stand of half-grown asparagus stalks covered the field. On September 7, this new growth was badly rusted, and by the first of October it was as nearly dead as was the first growth previous to cutting. As a result, the bed was so weakened that it had to be abandoned in 1900. The author believes that American writers never intended to recommend cutting early in the fall, although in an article in *Garden and Forest* Dr. Halsted[16] says, "The only safe thing to do when a serious enemy like this is in an asparagus field is to burn the plants even to the last scrap that can be gathered up. Let this be done at once, for any delay means the breaking up of the brittle, rusty plants, and a generous sowing of the spores upon the ground." Unfortunately Long Island growers are not the only ones who have tested cutting and burning too early in the fall.

In asparagus growing sections like Long Island where a large amount of asparagus grows wild in hedgerows and neglected fields, where also worn-out fields are allowed to run wild, it is doubtful if cutting and burning even late in the fall will ever be of much benefit. Even with a law compelling all growers to cut and burn their beds in October, it still remains an open question whether the spores which fall to the ground will not thoroughly seed the field for another season.

In addition to burning Dr. Halsted[17] has suggested plowing and the application of lime as a means of disposing of the scattered spores which lie on the surface of the field. This method may be worth a trial where level culture is practised, but would be of little value where ridging is followed.

RESISTANT VARIETIES.

In 1896 Dr. Halsted[18] noticed that the Palmetto variety was apparently not injured as much by the rust as some other varie-

[16] *Garden and Forest*, 9: 395, 1896.

[17] N. J. Agr. Exp. Sta. Bul. 129, p. 15.

[18] N. J. Agr. Exp. Sta. Rept. 1896, p. 409–410.

ties. A year later Mr. Kinney[19] reported the same condition in Rhode Island. During the past three years Dr. Halsted has reported the Palmetto as showing less rust than other varieties in New Jersey. As already stated, in 1900, recently-set Palmetto plants were injured more by the spring stage of the rust than were the Conover's Colossal plants of the same age in the same field. Similar conditions occurred on the fields of the Oneida Community Limited, in Madison County, New York. In one field containing several varieties, the Palmetto showed no advantage over the others. The fields on Long Island have been watched every year since 1896 with the result that only slight, if any, differences in favor of the Palmetto were to be noticed, except that in some cases it did not succumb as early. Of course there is a bare possibility that the Long Island growers have a weak strain of the Palmetto variety. More frequently greater differences would be seen in the same variety, apparently due to such factors as age of the bed, situation with regard to other fields and proximity of windbreaks. At present several other varieties are being advertised as "rust proof." Undoubtedly seedling varieties will be found which will succumb to the attacks of the rust more slowly than others; but as the beds get older or a little mismanagement exhausts them they will finally get started downward and then go under. Hence at present we would recommend that no one put too much faith in "rust proof" varieties and expect them to resist the continued attacks of the rust without some effort on the part of the grower to check the spread of the disease.

SOIL CONDITIONS.

Mr. Kinney,[20] Botanist of the R. I. Station, says: "So far as observed neither the character of the land nor the kind of fertilizer used, nor the method of cultivation practised has had any noticeable influence upon the development of the asparagus rust."

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[19] *Rural New Yorker*, 56: 658, Oct. 9, 1897; also R. I. Agr. Exp. Sta. Rept. 1897, p. 320.

[20] *Rural New Yorker*, 56: 658, Oct. 9, 1897.

Two years later Messrs. Stone and Smith,[21] of Massachusetts, say: "The injurious effects of the rust have been confined to dry sandy soils possessing little capacity for holding water. Where the soil is heavier, possessing more water-retaining qualities, the rust has caused no perceptible harm." In a still later report[22] the same writers endeavor to show "the susceptibility of plants growing in localities possessing soil with little water-retaining properties." Their conclusions are based upon an extensive study of the localities affected, also upon mechanical analyses of the surface soils from ten different sections of the State where asparagus is grown. They also assert that the summer (uredo) stage is limited in its distribution in Massachusetts and is found only on those soils which are sandy and possess little water-retaining properties, whether they are located near the coast or inland.

In conclusion they recommend the selection of soils, for new beds, which possess considerable water-retaining capacity, even if such soil is not adapted quite so well for asparagus during ordinary seasons. For old beds they recommend increasing the soil moisture by irrigation, by increasing the organic matter, and by mulching.

Unfortunately nearly all the asparagus sections of Long Island are situated in what Messrs. Stone and Smith have classed as coast lands. A few fields are situated in the drift soils of the terminal moraine, but for the most part they are situated on drift and wash sands. The best of the soils are what are called sandy loams. Differences due to what was considered the vitality of individual plants, also to protection by timber belts, corn fields and other windbreaks, have been observed. In no case in this section have differences been noted which could be traced to soil conditions. In many cases where the fields are situated on wash sands the water-table is so near the surface that the roots of the plants could easily reach the water; while the moraine soils often have a depth of fifty to one hundred feet to the water-table.

[21] Hatch (Mass.) Agr. Exp. Sta. Bul. 61, p. 19, 1899.

[22] Hatch (Mass.) Exp. Sta. Ann. Rept., 1899, p. 190.

Thus far the only differences to be seen in the Long Island fields were apparently due more to the fact that the rust got started earliest on the sandy lands and then drifted to the fields on the moraine soils. In all cases both the summer and winter stages were always present. Of course the fact of the rust starting on the low sandy lands may result from the influence of the factors set forth by Messrs. Stone and Smith. As will be shown further along we think a still different factor enters into the above conditions.

About the middle of September the writer visited the asparagus fields of the Oneida Community Limited and the surrounding country in Madison and Oneida Counties. He was first taken to a six-acre field situated in the bend of a stream, no point of which was over eight feet above the lowest stage of the creek. The surface soil of this field was called a clay loam, and was an alluvial deposit formed by a bend in the stream. The original banks of the stream consisted of a shaly clay and were some thirty feet higher than the asparagus field. The variety of asparagus on this field was Moore's Hybrid. The only portion of the field that was not entirely killed was on the tangent side of the bend next the original bank of the stream. This bank was covered with a vineyard and furnished a partial windbreak to the southwest of the asparagus field.

The next field of thirteen acres was a new bed of Barr's Mammoth asparagus set the spring of 1900. It was situated a half mile further down the stream, to the northeast of the first field but on the high ground, about fifty feet above the stream. The soil was a clay loam with a small amount of gravel intermixed. At a distance this field appeared to be entirely free from the rust; closer inspection showed that it was slightly infected with both the summer and winter stages of the disease. The same conditions on newly set fields had been noted on Long Island, namely, that the rust did not attack them until late in September, but in all such cases the fields were isolated and surrounded by woodland.

A third field of ten acres was next inspected. A small stream

runs through the latter and joins the larger stream. Part of the field had once been a swamp which had been drained and loamed before setting to asparagus. In fact one portion of this field showed a clay loam, another stiff clay, another clay with shale and cobble stones intermixed and still another was black muck loamed on the surface. No portion of the field is over eight feet above the water-table and over most of the field water could be reached within five feet. On this field there were growing nine rows of Palmetto and thirteen rows of Moore's Hybrid, the remaining rows being unknown varieties.

Only slight differences in the amount of rust on any of the above vareties were noticeable, the best portions showing the yellow-brown color of a badly rusted field. Both stages of the rust were found here.

A member of the Company, Mr. Hinds, kindly drove me to another field of fifteen acres located on higher ground. This field, consisting of Moore's Hybrid and Conover's Colossal, is situated on a side hill, the top being about eighty feet and the base fifty feet above the creek. The rows of asparagus are long and straight, not following the contour of the hill. The soil is a sandy loam with some clay and enough humus to make a black sandy loam. Apparently the soil is the same in all parts of the field. About one-third of the field consists of a new bed which had been set two years but had not come into cutting. This new portion is on the lowest part of the field, near the base of the hill. The remaining two-thirds of the field are older beds which had been cut for four or five years and at the same time had received liberal applications of stable manure, 15 to 20 loads per acre each year. This older portion covers the crest and upper half of the side of the knoll. Aside from manuring, the whole field had received the same cultivation the past year.

The asparagus on the top of this hill was so free from the rust that we had to search some time before finding an infested stalk. Following down the rows we soon came to a belt of yellowish-green plants; here the rust was plentiful. A little further down, the plants were all brown, with little foliage left, and still further

down the hill on the new bed the plants were naked and gray-black with *Darluca* and the winter stage of the rust. As in all the other fields both stages of the rust were found. The peculiar belts of brown plants with little foliage, yellowish-green plants with some foliage, and last the green plants showing very little rust, all following the contour of the hill and not limited to the new bed, were very marked. If these belts had been limited to the new bed and to only a small portion of the old bed adjoining, all the conditions might be accounted for by assuming that the rust had started early in June on the new bed and had gradually spread to the older bed after the cutting season was over. If the new bed had been so situated that prevailing winds could carry the rust to the older portion of the field, the conditions found could have been considered the result of the rust starting early on the new bed and spreading in curves by aid of the winds. As a matter of fact the rows run east and west, and the contour lines of the hill extend from south to north northwest, the slope being east northeast. The new bed is on the east end of the field. The slightly rusted portion of the field was on the crest of the knoll. Undoubtedly the rust had attacked the new bed early in the season, but this would not account for the rust belts following the contour of the hill and infecting the old bed on the north side. It was said that the rust affected the field in the same manner the previous year.

As far as known there are no tests showing that it is absolutely essential for the spores of the summer stage of the rust to have a nidus of water in which to germinate under natural conditions. It is an assumed fact among pathologists that the spores of all kinds of fungi, including the rusts, require drops of water in which to germinate. Water certainly is required to germinate them under artificial conditions. If this is a correct assumption, then the fact that an abundance of moisture had been furnished for the germination of the rust spores in the form of dewdrops, might account for some of the conditions found in the above field. Now it is often observed that low lands and those adjoining streams get heavier dews than does the high

ground; also, that air currents affect the distribution of the dews; that is, dews are not evaporated as rapidly on the windward side of a hill. Although the base of this field is as high as any of the fields of the Oneida Community Limited yet the land adjoining it on the northeast is low and moist. All these conditions indicated that dews might have had more to do with the fostering of the rust than had any other condition, such as cultivation, fertilization, soil conditions and varietal differences, which man could furnish. Taking the conditions as they were, it appeared that dews had been the principal fostering agent in the fields of the Oneida Community Limited, the only exception being in the case of the new field of Barr's Mammoth. This field, as stated, is about fifty feet above the stream and nearly level. In addition it is open to wind currents from all directions.

The supposition that fogs and dews have more to do with the varying conditions found regarding the rusting of asparagus fields applies in all cases on Long Island. It is a common occurrence to have a week or ten days during each month of the fall on which the sun is not seen until 10 a. m. The low grounds always get the larger portion of these fogs.

Although Messrs. Stone and Smith do not state whether the fields examined by them were on high or low ground, they give the post office address of each locality. A study of the contour map of the State of Massachusetts shows that four of these localities are less than one hundred feet above sea level; that is, they are in sections which are reached by sea fogs, while a fifth locality is in the valley of the Connecticut River. From what has been observed regarding conditions in this State it would seem as if the factor of fogs and dews might play an important part in the conditions found in the State of Massachusetts.

SPRAYING.

From the fact that all the true rusts which attack plants are internal parasites, that is, they grow and develop within the plant and do not show themselves on the surface of the plant until mature enough to form their spores, writers on plant diseases

have not considered spraying a very practical nor promising method of preventing the rust. In the special case of asparagus which has dense as well as very smooth foliage, spraying is a much more difficult task than is the spraying of many other plants. Still another difficulty which some have set forth as a disadvantage in asparagus spraying is the lack of suitable machinery to do the work on a large scale. In addition to the above facters the preliminary work done by Dr. Halsted[23] showed an advantage from spraying of only about 20 per cent. and more recently Dr. Halsted[24] has reported injury to asparagus from spraying. Basing their conclusions upon these results, combined with the difficulties to be overcome, several writers have questioned the advisability and economic value of spraying.

EXPERIMENTS ON LONG ISLAND, 1898–'99.

The results given by Dr. Halsted were based upon estimates of the percentages of rusty plants on sprayed plats and on unsprayed plats, a difficult method in the case of asparagus with its dense foliage. It appears that a much fairer method would be to select a cutting bed which is old enough to be in its prime, and determine whether any difference in yield by weight could be obtained as a result of spraying. Furthermore the persistence of the rust each year together with the resultant weakening of the beds and a decreasing yield as shown by the records of the canning factory, called for vigorous measures of some description. Hence in 1898 arrangements were made with Mr. Arthur L. Downs[25] of Mattituck, N. Y., to spray a portion of one of his Columbian White asparagus fields.

As this work was started too late in 1898 to carry out that year all the details required for a complete experiment, a trial

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[23] N. J. Agr. Exp. Sta. Bul. 129, also Rept. 1898, p. 345.

[24] N. J. Agr. Exp. Sta. Rept. 1898, p. 345, also Rept. 1899, p. 410.

[25] At the time, we were conducting some illustrative field work on pickle spraying on Mr. Downs' place, hence we had apparatus and materials handy for spraying of asparagus. Furthermore Mr. Downs is a practical and reliable farmer, a graduate of Cornell University, and a man interested in doing good, careful work, especially in experimental lines.

strip of three rows, one-fifth acre, was sprayed. The principal object of this test was to determine whether a resin solution could be used to advantage for making the Bordeaux mixture adhere to the foliage of the asparagus and at the same time not injure it.

NOTES.

The three rows were sprayed three times—August 5, 17, and September 1, one barrel of the resin-Bordeaux mixture[26] being used in each application. On September 9, a slight difference between sprayed and unsprayed rows could be seen. The unsprayed portion was stripped of its foliage and all dead by October 7; the sprayed rows held most of their foliage until killed by frost. Plates XII and XIII, taken September 27, show only

[26] Resin-Bordeaux mixture was prepared by first making the Bordeaux mixture in the usual way, the 1-to-8 formula being used and the amount of lime being determined by test; after which two gallons of stock solution of resin was added to every 48 gallons of the Bordeaux mixture, the whole being stirred. By testing it was found best to dilute the stock resin solution with 8 parts of water before adding it to the Bordeaux mixture, that is, in preparing a 50-gallon barrel of mixture, the copper sulphate and lime were diluted enough to make 40 gallons after which 2 gallons of stock resin solution was diluted to 10 gallons, then added to the Bordeaux mixture.

The formula for preparing a stock solution of resin has been given in Bulletin 144 of this Station, but for convenience it is repeated here. The proportions are as follows:

Resin	5 lbs.
Potash lye	1 lb.
Fish oil	1 pt.
Water	5 gals.

In preparing large quantities of the resin solution it was found unnecessary to follow all the precautions given in Bulletin 144; also that it could be prepared more rapidly by simply placing the oil and resin in the kettle, heating them until the resin was dissolved, then remove kettle from fire and allow the mass to cool slightly after which the solution of lye is added slowly, the whole being stirred while adding the lye. After adding the lye the kettle should be again placed over the fire and the required amount of water added. The whole should be boiled until the solution will mix with cold water, forming an amber-colored solution. Care should always be taken to have the resin and oil cool enough so that when the solution of lye or the water is added, the whole mass will not boil over and catch fire.

partially the apparent difference between sprayed and unsprayed portions of the field. The mixture adhered to the plants well and was not easily removed by rains. The main difficulty encountered was to get the workmen to keep the nozzles constantly under motion and at the same time reach all sides of the plants. The least hesitancy meant drenching the foliage until the liquid ran off in drops. No trace of injury to the foliage by resin-Bordeaux mixture was found. The outfit used for the spraying consisted of an "Eclipse" pump mounted in a barrel and carried in a two-horse cart. Two leads of hose were attached and each workman sprayed one side of a row at a time.

RESULTS.

In 1899, records in pounds and ounces of the cuttings from the center row, one-fifteenth acre, of the sprayed belt, and of an adjoining unsprayed row, were kept. The first cutting was made May 6, and the last one on July 1. In all forty-five cuttings were taken from each row, the amount of each cutting weighed separately. The asparagus was bunched and sold to the Hudson Canning Company at Mattituck, N. Y. Primes sold at 14 cents and culls at 6 cents per bunch.

On three dates the cuttings from each row were bunched separately. The weights of these cuttings, together with the number and value of prime and cull bunches, were as shown in the following table:

Table I.—Character and Value of Yield of Unsprayed and Sprayed Asparagus.

UNSPRAYED ROW.

Date. 1899.	Yield in pounds.	Bunches.			Value.		
		Primes.	Culls.	Total.	Primes.	Culls.	Total.
May 24	9.1	1.0	1.5	2.5	$0.14	$0.09	$0.23
June 9	9.8	2.0	1.0	3.0	0.28	0.06	0.34
June 19	10.8	2.5	1.0	3.5	0.35	0.06	0.41
Total	29.7	5.5	3.5	9.0	0.77	0.21	0.98
Average	9.9	1.8	1.2	3.0	0.26	0.07	0.33

SPRAYED ROW.

DATE. 1899.	Yield in pounds.	Bunches. Primes.	Bunches. Culls.	Bunches. Total.	Value. Primes.	Value. Culls.	Value. Total.
May 24..........	16.5	4.3	1.0	5.3	$0.60	$0.06	$0.66
June 9..........	14.3	4.0	1.0	5.0	0.56	0.06	0.62
June 19	17.7	4.7	1.0	5.7	0.66	0.06	0.72
Total	48.5	13.0	3.0	16.0	1.82	0.18	2.00
Average	16.2	4.3	1.0	5.3	0.61	0.06	0.67

AVERAGES.

Sprayed	16.2	4.3	1.0	5.3	$0.61	$0.06	$0.67
Unsprayed	9.9	1.8	1.2	3.0	0.26	0.07	0.33
Differences ...	6.3	2.5	—0.2	2.3	0.35	—0.01	0.34
Percentages ..	63.5	138.0	—16.0	76.0	134.00	—14.0	103.00

It will be seen from the above tables that the average weight of a bunch previous to trimming is approximately 3 lbs. (The cuttings were weighed before bunching; as a result the yield in pounds includes the weight of trimmings.) As the yield in pounds and ounces of the sprayed and unsprayed rows was kept the entire season, the total number of bunches obtained from the sprayed and unsprayed rows can be estimated. It can be shown from the first section of Table I, that 61.1 per ct. of the total average number of bunches for the three cuttings on the unsprayed row are primes, also that 38.9 per ct. of these bunches are culls; while from the second section it can be shown that 81 per ct. of the total average number of bunches for the three cuttings on the sprayed row are primes, and the remaining 19 per ct. are culls.

By first estimating the total number of bunches from the total yield of each row, then from the total number of bunches estimating the number of prime and cull bunches, and arranging these in a table together with the total yield, the difference between the sprayed and unsprayed row for the entire season will be as shown in Table II.

TABLE II.—TOTAL YIELD AND VALUE OF SPRAYED AND UNSPRAYED ASPARAGUS, 1899.

	Total yield in pounds.	Bunches.			Value.		
		Primes.	Culls	Total.	Primes.	Culls.	Total.
Sprayed row......	438.2	118.6	27.4	146.0	$16.61	$1.64	$18.25
Unsprayed row...	258.4	53.0	33.0	86.0	7.42	1.98	9.40
Differences	179.8	65.6	—5.6	60.0	9.19	—0.34	8.85
Percentage of gain	69.5	123.75	—17.0	70.0	123.75	—17.0	94.00

Table II shows: First, that the total yield by weight, and by bunches, of the sprayed row was nearly three-fourths more than that of the unsprayed row; second, that the prime bunches from the sprayed row were more than double the prime bunches obtained from the unsprayed row, while the culls from the unsprayed exceed the number of culls obtained from the sprayed row. The same conditions hold in values. These results are more marked when expressed in percentages. It should be remembered that each row represents one-fifteenth of an acre; from this it can be estimated that the total gain in value from spraying an entire acre would have amounted to $132.75.

The results brought out in the foregoing tables show distinctly that spraying asparagus to prevent the rust was not only a decided benefit to the sprayed rows but also to the grower, the value received for the increased yield being more than double the cost of spraying.

At the time of selecting the above field the growth was too young to show any appreciable difference in the rows. The three side rows were chosen as they could be reached with long leads of hose from the side of the field and in this way avoid driving over them. Later in the fall the indications were that the three sprayed rows had been in better condition previous to spraying than any of the unsprayed portion of the field. This difference may all have resulted from the spraying. In order to eliminate the advantage which outside rows usually show, the middle row of the sprayed belt was selected for keeping record

of yield. Hence the results as shown should represent approximately what can be done by spraying under favorable conditions.

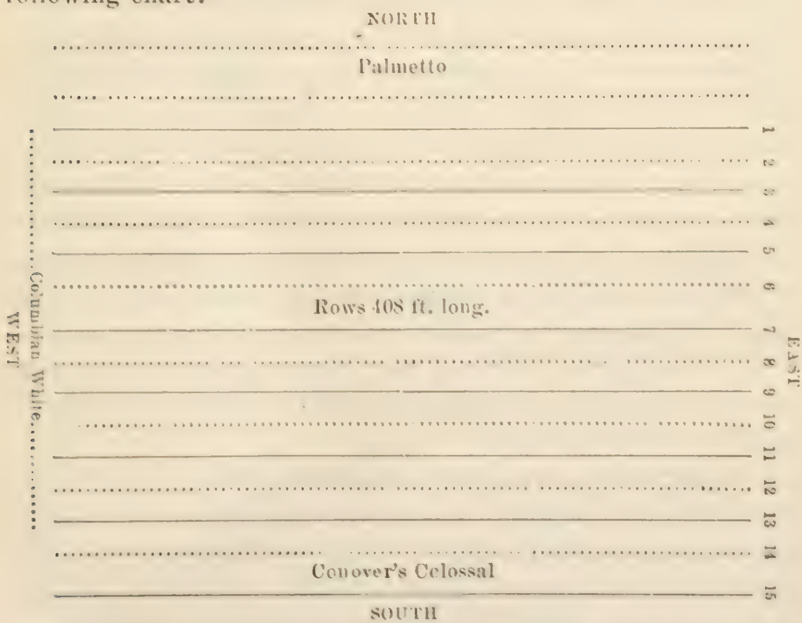
The fact that the area used as a basis was small, allowing factors of error to be exaggerated, lessens the value of the results as a whole, therefore conclusions as to the value of spraying should not be based upon these alone.

EXPERIMENT ON LONG ISLAND, 1899–1900.

As the field, a portion of which was sprayed in the fall of 1898, was not uniform in growth in all its parts, another field containing 15 rows, 408 feet long, set 6 feet apart, was selected. The conditions and treatment of this field are as follows: The field contains thirteen rows of Columbian White and two rows of Conover's Colossal, the whole having been set the spring of 1893. A new bed of Palmetto joins it on the north. The field is on the terminal moraine, the soil being a sandy loam. High grade fertilizers have been applied each year at a rate varying between 1500 and 2000 lbs. Some seasons the whole of the fertilizer was applied early in the spring after which the field was either plowed shallow or gone over with the disc harrow. Generally the last week in April two furrows are thrown to the rows after which the "ridger" is started and run every Saturday throughout the cutting season. Before each ridging the cultivator is usually run between the rows to loosen the soil. At the close of the cutting season, usually July 1, the ridges are plowed down and if all the fertilizer was not applied in the spring the remainder is put on after "plowing down." During the summer and fall growing season the field is cultivated every week or two until the ground is covered by the growth of asparagus tops. Usually the old tops are not removed until the following spring.

The plan followed was: First, to determine the yielding capacity of each row of the entire field previous to spraying, by weighing each cutting; second, to spray the growth on each alternate row during the fall; and third, during the next season, to weigh each cutting from each row as in the previous spring.

The cutting on this field was begun May 6, 1899, a total of forty-five cuttings being made in each row. The amount taken from each at each cutting was weighed separately and a record kept of the weighings. In this way we obtained the yielding capacity of each row. It was found that the rust had reduced the vitality of the field until it was yielding very lightly. The last cutting was made July 1, after which the field was plowed down and allowed to grow. On July 28, the spraying was commenced, every other row being sprayed. The odd numbers were sprayed, the even numbers being left as checks, as shown in the following chart:



The 1-to 8 formula Bordeaux mixture with resin solution added was used as in the fall of 1898. In all, five applications were made, the dates being July 28, August 10 and 26, September 6 and 14.

NOTES.

The rust (summer stage) showed on the unsprayed rows August 19, and by August 24, had spread to all parts of these rows. They were killed by September 10. The sprayed rows

remained green until the middle of October, but observation showed that it was only the growth made between July 1 and August 10 that survived the attacks of the rust until October 15; that is, a growth that was completed, hardened, and thoroughly sprayed before the rust struck the bed. All the new sprouts which came up in the sprayed rows after the rust appeared in the field were destroyed. There were two and possibly three of these periods of late growth, namely, about August 15 and September 15. As in tests of 1898, the asparagus foliage was not injured in the least by the resin-Bordeaux mixture. Tests in laboratory showed that the solution of copper sulphate could be neutralized by the use of the resin solution alone, but a mixture of resin soap resulted which would have been impossible to spray. Possibly the excess of potash in the resin solution was the neutralizing agent and not the resin itself. Whichever it was, this is certain: that by first making the Bordeaux mixture with lime in the usual way, and then adding the stock resin solution at the rate of one gallon to twenty-four gallons of Bordeaux mixture, a fungicide was obtained which has not injured the asparagus foliage in the least during three seasons' trials, namely, 1898, 1899 and 1900; furthermore, the resin solution aids somewhat in making the mixture adhere to the smooth surface of the asparagus.

During 1900 the crop cut from all the rows of the test acre was weighed as in 1899. As the fifteenth row showed a slight advantage in yield (about 18 pounds) over the other rows previous to spraying, its yield is not included in the tables, although it was sprayed, hence the sprayed portion was two-fifths of an acre.

RESULTS.

The first cutting in 1900 was made May 14, and the last on July 2, the total number of cuttings being thirty-eight. This method gave us not only the yield of the sprayed rows before and after spraying, but also the yield of the adjoining unsprayed rows for two seasons.

The preliminary cuttings made in the season of 1899 brought

out the fact that a factor of error was introduced in cutting which affected the weights. This occurred as follows: The method of ridging every Saturday favored the cutting of larger stems, hence, of more primes, early in the week, but also more pounds of waste when bunched. Toward the end of the week as the ridges were worked down in cutting, careless cutters would cut too short making more culls but at the same time reducing the amount of waste in pounds when bunched. Furthermore, no two persons would get the same results in cutting, nor would the cuttings of one person be the same before and after a rain. Hence in 1900 the cuttings from seven sprayed rows were bunched by themselves, as were also those from the seven unsprayed rows, and a record kept of the bunches obtained at each cutting. This gave us not only the total yield of primes and culls in addition to total yield in pounds, from sprayed and unsprayed rows, but also the money value of the sprayed and unsprayed crops. As in 1899, the primes were sold for 14 cents and the culls for 6 cents a bunch. The following tables show only summaries of weights. The records of the weights and bunches of each cutting are too bulky to be presented in tabular form.

TABLE III.—YIELD OF SPRAYED AND UNSPRAYED ASPARAGUS.

SPRAYED.

	Row 1. *Lbs.*	Row 3. *Lbs.*	Row 5. *Lbs.*	Row 7. *Lbs.*	Row 9. *Lbs.*	Row 11. *Lbs.*	Row 13. *Lbs.*	Total. *Lbs.*
1899	93.4	115.4	116.8	114.4	106.9	102.8	115.1	764.8
1900	115.4	127.0	137.3	125.6	120.8	115.0	134.4	875.5
Gain	22.0	11.6	20.5	11.2	13.9	12.2	19.3	110.7
Percentages	23.5	10.0	17.5	9.8	13.0	11.8	16.8	14.5

UNSPRAYED.

	Row 2. *Lbs.*	Row 4. *Lbs.*	Row 6. *Lbs.*	Row 8. *Lbs.*	Row 10. *Lbs.*	Row 12. *Lbs.*	Row 14. *Lbs.*	Total. *Lbs.*
1899	104.4	114.2	110.6	116.4	109.4	110.8	105.4	771.2
1900	77.9	92.1	79.0	95.0	75.3	85.8	87.3	592.4
Loss	26.5	22.1	31.6	21.4	34.1	25.0	18.1	178.8
Percentages	25.5	19.0	28.5	18.0	31.0	22.5	17.0	23.0

GAINS AND LOSSES.

	Rows 1 and 2.	Rows 3 and 4.	Rows 5 and 6.	Rows 7 and 8.	Rows 9 and 10.	Rows 11 and 12.	Rows 13 and 14.	Total.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Sprayed	22.0	11.6	20.5	11.2	13.9	12.2	19.3	110.7
Unsprayed	26.5	22.1	31.6	21.4	34.1	25.0	18.1	178.8
Total gain......	48.5	33.7	52.1	32.6	48.0	37.2	37.4	289.5

The first section of Table III shows the yield in pounds of each sprayed row, also the total yield of all the sprayed rows before and after spraying, together with the differences of the yields for two years. This table shows a gain from spraying on every row, and a total gain on two-fifths acre of 110.7 lbs., an average gain of 276.7 lbs. per acre.

The second section shows the yield of each unsprayed row, also total yield, in pounds, of unsprayed rows for two years, together with the differences in yield. In every case these unsprayed rows show a decreased yield the second year, a total decrease exceeding the total increase of the sprayed rows in a ratio of approximately 3 to 2.

This method of showing the increased yield from the sprayed row, and the decreased yield from the unsprayed row, does not show the whole advantage of the treatment, at least in the way generally followed. The sum of the increase and decrease as shown in the third section of Table III, comes nearer the method usually adopted.

By this method the total increase as a result of spraying two-fifths acre will be 289.5 lbs., or at the rate of 723.75 lbs. increase per acre.

The method usually followed to show the advantages or disadvantages of any method of treatment is to compare the yield of the treated with that of the untreated for one season, as shown in Table IV.

TABLE IV.—COMPARISON OF SPRAYED AND ADJACENT UNSPRAYED ROWS, 1900.

	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Total pounds
Sprayed rows...	115.4	127.0	137.3	125.6	120.8	115.0	134.4	875.5
Unsprayed rows.	77.9	92.1	79.0	95.1	75.3	85.8	87.3	592.5
Gain	37.5	34.9	58.3	30.5	45.5	29.2	47.1	283.0
Percentages ...	48.0	37.8	74.0	32.0	60.5	34.0	54.0	47.8

This table shows that there is a gain in yield of the sprayed over the unsprayed rows in every case. The total gain on two-fifths acre is 283 lbs., or at the rate of 707.5 lbs. per acre, an increase of 47.8 per ct.

As a record of the prime and cull bunches from the treated and untreated rows was kept and the value of the bunches known, the results can be compared in values and bunches as well as in total weights. Table V shows not only the total weights from sprayed and unsprayed rows, but also the total primes and culls from each, together with their values and their differences.

Table V.—Total Yield and Value of Sprayed and Unsprayed Asparagus, 1900.

	Total yield in pounds.	Bunches.			Value.		
		Primes	Culls	Total.	Primes.	Culls.	Total
7 sprayed rows....	875.4	192.6	83.4	276.0	$26.96	$5.00	$31.96
7 unsprayed rows..	592.4	121.9	84.1	206.0	17.06	5.04	22.10
Differences	283.0	70.7	—.7	70.0	$9.90	—.04	$9.86
Percentages of gain	47.8	58.0	—.8	34.0	58.0	—.8	44.5

In general this table shows the same conditions throughout as Table II which shows results for 1899, though the differences are not as marked. When the results are compared on the same basis, namely, as percentages, it will be seen from Table II that the percentage of yield is less than the percentage of value, while in Table V these conditions are reversed. Evidently this variation results from the varying yields of primes and culls combined with the difference in price received for them. Hence the introduction of the bunches as a means of obtaining more accurate results, while furnishing a method of determining and comparing the values, at the same time introduces another factor of variation.

Taking the results of Table V as they are, the increased money value received from spraying two-fifths acre was barely enough to cover the cost of spraying the same. It should be remembered that the yields for 1899, previous to spraying, showed that the yielding capacity of this field as a whole was very small. The

age of the field was such that it ought to have been in its prime, but previous attacks of the rust had injured it so severely that the yield was only about one-half the average yield per acre throughout the Long Island asparagus section for the season, as the records of the Canning Company show that the average yield per acre for 1900 was about 800 bunches. In reality the yield of this field was only about one-third what a good field should yield. As an outcome, with all the precautions taken to eliminate uncertain factors, the results obtained as a whole were not as marked as were those in 1899. Some idea of the growth of asparagus on this field can be obtained from Plates XIV and XV taken the middle of September, 1900.

By giving the results as percentages the above conditions are somewhat eliminated and the yields expressed in this manner probably show accurately what can be done by spraying under the most unfavorable conditions. These conditions were: First, a field with a low yielding capacity; and second, a field having alternate unsprayed rows as a constant source of infection to the sprayed rows. In addition it should be observed that the even or unsprayed rows showed a slight advantage over the sprayed rows in yield previous to spraying. See Table III.

With all these disadvantages to contend with, the increased yield from spraying shows in percentages a gain in yield of 47.8 per ct., and in value 44.5 per ct. This amount can surely be taken as representing what is to be gained from spraying alone without the aid of any other measures or methods.

It can be shown that the average yield in bunches from the Long Island fields the past year was between 750 and 800 bunches per acre. The records of the Canning Company also show that previous to the attacks of the rust the same fields yielded between 1,500 and 2,500 bunches per acre. It must not be assumed that from the fact that spraying gave an increased yield of 45 per ct. over unsprayed rows that the average yield of 800 bunches can be increased that amount. This percentage simply means that the yearly decrease in yield from the attacks of the rust can be reduced 45 per ct. Yet a study of Table III would indicate

that there was an actual increase in yield of 14.5 per ct. from spraying.

THE PARASITIC *DARLUCA*.

In 1898 Dr. Halsted[27] found a fungus known as *Darluca filum* Cast., which is a parasite upon many rusts, attacking asparagus rust.

This parasitic fungus has been so prevalent during the past two years that most growers of asparagus are familiar with it. Its abundance and the rapidity with which it spreads upon the uredo or summer stage of the rust has led others besides growers to anticipate remarkable benefits from its attacks on the rust.

During the past summer (1900) *Darluca* attacked the æcidial stage of the rust about June 10. Ten days later all the rusted asparagus stalks were covered with the *Darluca*. Notwithstanding the above condition, there was a severe outbreak of the summer stage of the rust on seedling beds about July 1, which was immediately followed by the *Darluca*. About the middle of August as severe an outbreak of the summer stage of the rust as has ever occurred in previous years appeared on the cutting beds. This in turn was followed by the *Darluca*. The same conditions were repeated again in September on the late watery shoots of asparagus. All of these attacks of the *Darluca* were followed by the formation of an abundance of the teleuto spores or winter stage of the rust.

Cross sections of the sori or rifts of the summer stage of the rust frequently show the condition illustrated in Fig. 2, Plate XI, that is, the sori will be filled with the uredo or summer spores while beneath them a layer of the winter spores will be forming. We have even found sori in which the uredospores were apparently destroyed by *Darluca* while at the bottom of the sorus a layer of evidently healthy winter spores would be found.

The formation of the winter spores of the rust on the same plant where the uredo stage had been attacked by *Darluca*, combined with the conditions shown in Fig. 2, Plate XI, all indicate that the *Darluca* attacks the spores of only the æcidial and uredo

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[27] N. J. Agr. Exp. Stas. Bul. 129, p. 15.

stages and does not injure the vegetative portion or that which answers as the root system of the rust. As yet it has not been shown that the *Darluca* ever attacks the thick-walled winter spores. Hence the indications are that *Darluca* will not exterminate the rust nor even act as a material check, especially where asparagus is grown in large quantities.

Dr. Pammel[28] states that *Darluca* has more delicate spores than the rust and is more susceptible to the spray of the fungicide.

During the past three years no appreciable difference in the amount of *Darluca*, on sprayed plants which had become rusted and on unsprayed rusty plants, has been observed.

CONCLUSIONS.

All three stages of the asparagus rust occur in New York State. The first stage is usually found on seedling and neglected beds only. The uredo and teleutospore stages can both be found on the same plant at the same time whether it be June or October. Furthermore both stages may occur together in the same rift or sorus.

Cutting and burning too early in the fall is injurious. Late burning admits of scattering of the spores, and combined with this is the ever present fact of neglected fields and volunteer asparagus as a source of infection; hence it is a question whether burning is a profitable or even a practical method to follow in combating asparagus rust.

Thus far no variety of asparagus has entirely withstood the attacks of the rust in this State. In instances where one variety has shown slight advantages it was questionable whether the difference was not due to age or surrounding conditions instead of to any inherent qualities.

Although Messrs. Stone and Smith assert that there is a variation in the distribution and attacks of the rust due to different soil conditions and that the uredo stage is limited to sandy soils in Massachusetts, no such variations have been observed in this State. Furthermore it appears from conditions found here

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[28] Iowa Agr. Exp. Sta., Bul. 53, p. 64, 1900.

that the factor of fogs and dews may play a more important part in the distribution of the rust than soil conditions.

The results obtained in 1898–99 show conclusively, not only in appearance of the sprayed and unsprayed belts, but also in the yield, that spraying not only protected the asparagus from the rust but in addition was a source of profit. Nevertheless, the fact that the area used as a basis was small, allowing factors of error to be exaggerated, lessens the value of these results as a whole. Hence conclusions as to the value of spraying should not be based upon these alone. The resin-Bordeaux adhered fairly well and did not injure the asparagus in the least, although the 1–to–8 formula was used in preparing the mixture.

Observation brought out the fact that only the growth made previous to the appearance of the rust on a field was protected by spraying; that is, a growth that was mature and thoroughly sprayed previous to the attacks of the rust. This observation applies only to the field where every other row was a source of infection. Furthermore it was observed that generally two and sometimes three periods of growth occur in Long Island asparagus beds, and for two seasons, 1899 and 1900, we have been unable to save these late growths on the test field. Hence the indications are that, even with spraying, the vitality of the sprayed rows on this field will be gradually reduced.

As already stated the resin-Bordeaux mixture caused no apparent injury to the asparagus. In fact no noticeable injury has resulted from the use of the resin-Bordeaux mixture, used as strong as 1 to 8 during three seasons.

It was found necessary to use between 250 and 300 gallons of the mixture per acre at each spraying when applied with a barrel pump. In addition it was ascertained that with an ordinary barrel pump with two leads of hose three men could not prepare the mixture and spray over three acres per day.

Thus far the results show that under the most unfavorable conditions a gain in yield of nearly 50 per ct. can be obtained by spraying, while under more favorable conditions a gain of nearly 70 per ct. in yield can result from spraying. Expressing the

results in values, under unfavorable conditions a gain of nearly 45 per ct. was obtained, while under more favorable conditions the gain was nearly 95 per ct.

Darluca filum has been abundant on asparagus rust for two seasons and has been found attacking the rust in all its stages except the black or winter stage. Thus far no apparent checking of the injury caused by the rust, by the attacks of *Darluca* on the rust, has been observed; nor has any checking of the spread of *Darluca* by spraying been noticeable.

RECOMMENDATIONS.

Thus far the results obtained from spraying asparagus are marked enough to warrant the recommendation of spraying with resin-Bordeaux mixture in general as a means of controlling the asparagus rust.

It has been shown that on the test field, even with spraying, the rust destroyed the late growths of asparagus, with a consequent weakening of the plants. This in time would reduce the yield below a profitable point and spraying would only add to the expense of getting the reduced crop. Furthermore the work done brought out the fact that spraying asparagus thoroughly results in considerable expense and labor. Whether the cost of spraying can be reduced cannot be stated until after further tests have been made. Even without considering the latter factors it is evident that spraying alone will not wholly protect the crop. Whether varieties will be found which will resist the attacks of the rust entirely, or whether cultivation and soil conditions will prove a check to the attacks of the rust are factors still to be proven. Hence in consideration of all these facts, spraying should be undertaken with the determination of doing it thoroughly; and with the expectation that the rust will gradually reduce the vitality of the field even with spraying. Possibly the selection of those varieties which show some resistance to the rust combined with proper attention to cultivation and feeding of the crop, including the use of vegetable matters with the fertilizers used, will aid in preserving the vitality and do much toward obtaining better results from spraying.

Simply as an opinion, we will say that by spraying twice a week we believe that young, rapid-growing shoots can be protected. That the apparent inability to get the mixture to adhere to them is due to the rapid growth of the plants, a factor which can be remedied by more frequent applications.

Spraying alone cannot be expected to be profitable on fields already reduced to one-third their original yielding capacity, nor can it be expected to revive such fields.

Basing a recommendation upon the results obtained combined with observation and experience in spraying of asparagus, we believe that it will pay all growers who have fields yielding 800 bunches and over per acre, to spray. In addition we would recommend the planting of corn on all sides of the asparagus field as a windbreak. Proper cultivation, fertilization and green manuring or supplying humus in some other form, follow as common-sense measures.

Where growers have a number of acres to spray we would recommend the construction of a power sprayer similar to the one described in Part II.

II. THE DOWNS POWER ASPARAGUS SPRAYER.*

INTRODUCTION.

In the chapter on asparagus rust it has been shown that spraying asparagus is not an easy task. As has been stated, one of the reasons set forth as a factor against spraying asparagus, is the lack of suitable machinery for doing the work. It was also found to be a difficult matter for workmen to do the spraying by hand with the thoroughness necessary to make it of much value. In fact lack of thoroughness means complete loss of time and materials, for after the rust gains a foothold within the plant, spraying is of little value. Lack of thoroughness does not neces-

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*As it is impossible for the writer ever to repay Mr. Arthur L. Downs, not only for bearing part of the expense, such as furnishing wheels, tank and truck, for the power sprayer, but for aid furnished in designing and putting into working order the above named machine, it is proposed that this be known as the Downs Power Asparagus Sprayer.

sarily result from any intentional neglect on the part of workmen, but from the impossibility of always reaching all parts of a heavy row without drenching some of the foliage so that the liquid will not adhere. In the work for 1899 an outfit was used consisting of a barrel pump fitted with two leads of hose and requiring three men and a team to operate successfully. With this equipment three acres is all that can be sprayed in a day if the work be done with any pretense of thoroughness. Furthermore it was found that for full-grown, heavy asparagus between 250 and 300 gallons of Bordeaux mixture was required per acre, when applied by hand machinery.

The expense is great in hand spraying, as a team and three men are required to spray three acres per day; and the labor involved in handling nearly 1,000 gallons of liquid is not slight. The treatment must be repeated once a week for four or five weeks or oftener while the asparagus is growing rapidly; surely not an encouraging prospect for asparagus growers who have five acres and upwards, and especially for those who grow from forty to sixty acres. In fact, with unfavorable weather, those with five or six acres would need to devote the major portion of their time to asparagus spraying, with a bare possibility of saving 40 per ct. of the crop.

The above factors, combined with the apparent success of our work in the fall of 1898 and of 1899, led to the designing and building of a power sprayer which it was hoped would do the work more thoroughly and rapidly than was possible to do by hand, the cost of the machine being a secondary matter. In order to secure efficiency the following conditions had to be met:

For economy in time the apparatus should have a tank capacity of at least 250 gallons; it must have a distributing capacity of that amount per hour, as a team walking at its normal rate will cover an acre of asparagus set in 6-foot rows in that time and thorough hand spraying requires 250 gallons of Bordeaux mixture per acre. The nozzles must be adjustable; as it is often desirable to spray the asparagus when small and as the rows on different beds are set at varying distances apart, from 4 to 7 feet.

The free space between the rows will also vary with the age of the bed.

The mixture should strike the plant from all directions at the same time without having the jets of spray conflict. Theoretically with a machine which would stop an instant at each plant, this could be done by the employment of five nozzles to a row, but in a moving machine the resultant direction of the jets of spray requires the use of ten nozzles for efficient service. Later it was found necessary to use twelve nozzles to a row, especially on full grown, vigorous beds.

In addition to being adjustable it was desirable to be able to elevate the nozzles from between the rows when turning around at the end. It was found that thrifty plants, in rows six feet apart, nearly covered the ground, hence it was essential to devise a means for lifting the asparagus before the spray reached it. This was necessary, not only in order to do the work thoroughly, but also to prevent tearing the nozzles from their carriers.

With all these conditions to be met the machine described and illustrated in the following pages was designed and built. As spraying may prove to be an aid to many growers in preventing the asparagus rust, the following detailed description of the machine and its parts is given, with notes upon some of the weak points and suggestions for remedying them. The machine is not patented and it is hoped that growers may make use of the ideas and suggestions in the construction of machines of less cost, thus lowering the expense of spraying.

DESCRIPTION.

THE TRUCK.

Several conditions had to be met in constructing a truck. The height required to clear the asparagus is one factor. At first it was thought that this could be disregarded by constructing a narrow-tread machine which would go between the rows, but such a machine would be difficult to get through the rows of full grown asparagus, and could carry only a small weight of liquid. These considerations led to the abandonment of this scheme. The desirability of carrying a large amount of liquid, and the neces-

sity of straddling the row led to the construction of a larger truck with arched axles which would clear the asparagus without injuring it. The sides of the arches were constructed of one and one-half inch square iron, the latter being bent at top and bottom. The top angles were flattened for attachment to an oak plate which formed the top of the arch, while the bottom angles formed the spindles for the wheels. The width of space at base of these arches is 4 feet 1½ inches, while at the top this space is 3 feet 6 inches. The slant height of front arch to arch-plate is 2 feet 5 inches; slant height of rear arch to arch-plate 1 foot 10½ inches. Both arches were braced, each brace being 2 feet 6 inches long, made from inch iron. The arch-plate clears a space of 4 feet. The arrangement and sizes of parts of front truck are shown in Fig. 1, Plate XVII. As it would have been bad mechanics to draw all the load from one point at top of the front arch, especially with wheels which had a tread of 6 feet, a double-tree was attached to the pole and then connected with the axle of each fore-wheel so that enough of the load was drawn from the latter points to remove all side wrench on the arch. (See Plate XX.) The arch-plate of rear arch forms part of the whole framework and is shown in Plate XVI. The tool box is shown only in photographs.

With the exception of the brake-bar, the 2x4 inch cross plate at rear of frame, and the 2x3 inch diagonal plates which support the carrier, all the wood parts are of oak. The brake-bar, the diagonal carrier-supports, and the cross plates on which the latter rest, are of pine. A clear space of 2 feet 11 inches was allowed between the side plates. At points *i i i*, Plate XVI, three half-inch iron plates are attached for carrying the upper half of the fifth-wheel and serve as partial supports for the tank. Across the rear end an oak plank 14 inches wide was bolted to side-plates as a support for the pump. In addition a second plank shown in Plate XVI was bolted to the above cross plank and to rear arch-plate for attachment of fulcrum to clutch-brake. The lengths and sizes of timbers are as shown in Plate XVI.

The wheels are iron, having 4-inch tires one-half inch thick, and guaranteed to carry from 8,000 to 12,000 lbs. The rear wheels

are 50 inches in diameter. The fore-wheels are 40 inches in diameter. They were obtained of the Electric Wheel Co., Quincy, Ill.

TANK.

A half-round tank was obtained from Thompson, Habmar and Fisher, Tonawanda, N. Y. It is made of 1¾ inch cypress, the top cross plates being 2x5 inch oak. Dimensions 6 feet by 2 feet 9½ inches by 1 foot 9 inches, capacity 250 gallons.

GEARING.

The pump is geared to the left hind wheel by means of chains combined with a shaft and four sprocket-wheels. The large sprocket-wheel, which is attached to the truck wheel, has a diameter of 25 inches and bears 49 teeth. The small sprocket-wheel on end of shaft is 8½ inches in diameter, and has 16 teeth. The large sprocket-wheel on shaft has a diameter of 17 inches and carries 32 teeth. The small 8 toothed sprocket-wheel on crank shaft of pump has a diameter of 5 inches. A "clutch-gear" is attached to large sprocket-wheel on shaft. The size of chain used is No. 45.

PUMP.

The selection of a pump was not an easy matter. It was necessary to have a pump that would throw at least 300 gallons per hour. Rotary pumps would meet the above requirement, but these have usually been found short lived when used for pumping Bordeaux mixture. The addition of the resin solution is hard on single plunger brass pumps and would make matters worse in the case of rotary pumps. No manufacturers of single or even double-plunger brass pumps would warrant their pumps to throw 300 gallons per hour, nor could any of them tell how high it would be necessary to speed such a pump to make it throw the required amount.

It was finally decided to test a single-acting triplex pump made by the Gould Manufacturing Company, Seneca Falls, N. Y. This pump was scheduled to make 50 revolutions per minute and throw 360 gallons per hour. It had the disadvantage of having

the water-box constructed entirely of iron; only cylinders, glands and plungers being of bronze or bronze lined. As manufactured these pumps are geared back 5 to 1. All the gearing was removed and a small sprocket-wheel attached directly to crank shaft. This pump had the advantage over single-cylinder pumps of maintaining a nearly constant pressure without the aid of an air chamber. The position of the pump and the method of connecting with tank and carrier are shown in Fig. 2, Plate XVII.

CONNECTIONS.

The pump used had $1\frac{1}{4}$ inch suction and discharge hence $1\frac{1}{4}$ inch connections were used throughout. The method of connection and arrangement of parts is shown in Fig. 2, Plate XVII. The use of a style of shaft and gearing given later would permit of the pump being placed nearer the tank and the use of shorter nipples. The distance between the first gate-valve and lock-out connecting to tank is $7\frac{1}{2}$ inches. The gate-valve, also the Ts, are standard trade lengths and sizes. A T, with valve connection as shown at *h*, Fig. 2, Plate XVII, was placed next to the pump for two purposes. It is desirable to run clean water through the pump without having to run it through the tank. Furthermore it was necessary to arrange to drain the pump from both sides. This T and gate-valve also allow of emptying the tank through the suction pipe.

A shut-off valve was placed in main supply pipe at *u v*, for the purpose of maintaining the pressure when the machine is stopped, also to hold the liquid in the carrier. This proved to be of little value. A T was used in connecting main supply pipe with pump for the purpose of attaching a pressure valve and return overflow pipe. At the same time the latter valve was used as means of draining the outer side of the pump and the main supply pipe. A power pump should be so geared that it will give good pressure no matter how slow the team moves, hence the necessity of a pressure valve to allow of pumping back into the tank when the speed of the machine is increased. The pres-

sure valve and return overflow pipe, with connections, are 1 inch.

NOZZLE-CARRIER.

All the foregoing parts are simply necessary means to an end, which any mechanic unfamiliar with spraying could easily have designed. The most difficult problem of the whole machine to work out was the nozzle-carrier. In order to do the work thoroughly it is necessary for the spray to reach the plants from all directions.

In a moving machine this must be accomplished by arranging the nozzles to spray forward and backward from above and diagonally forward and backward from the sides at both top and bottom. At the same time provision must be made for treating rows set different distances apart, also of varying widths, and asparagus of different sizes, and for elevating the nozzles when turning at the ends of the rows. The whole problem was finally solved by the combination of union joints allowing shear motion, and telescoping joints. The union joints are useful not only in allowing of a shear motion but also to give direction to the nozzles.

At first it was thought necessary to have the telescoping joints of ground tubing, and a carrier was constructed on this principle. By trial it was found that ordinary iron sizes of brass tubing, such as are handled by the trade, could be packed tightly enough to prevent leakage and answered the purpose better than ground tubing, as joints made with the latter soon became so gummed with the resin solution as to be nearly immovable. The essential parts of this nozzle-carrier are shown in Figs. 3 and 4, Plate XVII, and most of the parts are self-explanatory. Fig. 4 connects with Fig. 3 by means of a T shown at *g*. Fig. 3 shows one-half of the carrier and connects with main supply pipe, Fig. 2, at *y*. The number and arrangement of the nozzles are shown in the various photographs which illustrate the machine as a whole in different positions and at work. All the parts with which the Bordeaux mixture comes in contact are constructed of brass.

The unions are brass with ground joints and those shown at *u*, Fig. 4, which allow of the shear motion of the arms, are fitted with set-screws to prevent unscrewing of the union. The horizontal lengths of pipe shown in Fig. 3, were cut approximately two feet long. The horizontal telescoping joints allow of closing the carrier for four-foot rows, or of extending it for seven-foot rows. The lengths of pipe which form the vertical supply pipe, shown in Fig. 3 and Fig. 4, also those which form the arms, were cut approximately 18 inches long. The telescoping of the arms combined with the shear motion is an essential feature in adjusting the nozzles for different heights and widths of rows. It is still an open question whether the vertical telescoping joints shown at *j'* are of any real merit. One point is certain, the use of a telescoping joint in the vertical supply pipes which carry the arms necessitates extra fixtures and adds to the weight. The rods shown at *r*, Fig. 3, were provided to prevent twisting and slipping of the arms on the above joints, but as these proved more ornamental than useful for this purpose, an iron bar, shown at *b*, Fig. 4, was added. The latter prevents the twisting; it also strengthens the leverage for lifting the arms when turning around; at the same time it prevents sliding of the vertical joints. By the use of the above bar, the rods shown at *r*, Fig. 3, are not essential.

At first the elbow put out with the " Erin " nozzle by the Gould Manufacturing Company, was used for attaching the nozzles. These proved to be too weak for practical use so were abandoned and eighth-inch ground brass unions substituted. By the use of a short piece of bent tubing these unions gave nearly as much freedom of direction as did the elbows. At the same time the unions would turn before breaking or wrenching off, but could be screwed tight enough to hold the weight of the nozzle.

The size of tubing used in arms was one-eighth inch, telescoping into one-half inch, iron pipe sizes. The vertical supply pipes consisted of one-inch pipe telescoping over three-fourths inch pipe. The latter is not iron pipe size. The same dimensions

were used for the horizontal telescoping sections. The use of one-eighth inch tubing at end of arms together with one-eighth inch T's and unions necessitated bushing the nozzles. The arms are adjusted, with regard to position, by means of a sliding sleeve attached to the vertical supply pipe. The motion is conveyed by means of adjustable levers which connect with a clamp on each arm. The sleeve is held in position by means of collars provided with set-screws.

It has been stated that the utility of the telescoping joints in the vertical supply pipes carrying the arms, is doubtful. This does not apply to any of the other telescoping joints. The horizontal telescoping joints not only allow of contraction and extension of the carrier for rows set different distances apart but also serve the purpose of a hinge joint when the arms are lifted for turning around. Those of the arms not only allow of lengthening of the arm but also prevent breaking or wrenching of the carrier when nozzles are caught in the asparagus. This results not only from the ability of the joint to twist but also to pull out entirely, yet the joint can be packed firmly enough to prevent leakage and shaking or falling out. In fact, the combination of telescoping and union joints answers the purpose of ball and socket, or universal joints.

The method of attachment of carrier to pump is shown in Figs. 2 and 3. This connection serves as a partial support. The carrier also rests upon the horizontal supports connected with framework of truck as shown in Plate XIX, and upon an iron brace shown at *b*, Plate XVII. The same parts are shown in the various other illustrations. In addition it is anchored at points $b,^1$ $b,^1$ Plate XVII. These not only help to hold and steady the carrier but also serve as guides when lifting and adjusting the parts.

The brake for lifting the arms is anchored to the cross of the main supply pipe at *x*, Fig. 3, Plate XVII, while the brake bar is attached to lateral supply pipe as shown in Fig. 4, *o*, also in Plate XVI, *o*. The work of this brake is shown in Plates XIX and XX.

It will be seen that the carrier of this machine is so constructed that after the first round it sprays two rows at a time, or, rather it sprays one row completely and one side each of two other rows. The reasons for constructing the carrier in this way was, first, that it makes a balanced piece of apparatus. Second, with a heavy machine, carrying such a weight of liquid it was desirable to cover as many rows at a time as possible. When it was desired to spray a single row caps were placed on the ends of the outer telescoping tube of the outside arms.

LIFTERS.

Another feature, and one that was found necessary after the machine had been put in working order, is the lifters or rakes. These were found indispensable not only as a protection to the carrier arms but also to lift the asparagus so that it could be sprayed to better advantage. It is essential that the lifters should be adjustable, hence the principle of telescoping was again employed. It was found that rake teeth would injure the asparagus the least, be the least in the way, and add the least amount of weight. Two teeth were employed for each pair of lower nozzles. As shown in Plates XVIII and XIX, they were attached to horseshoe shaped pieces of iron, one tooth being set ahead of the other; the object being to have the forward tooth partially lift the asparagus, the rear one to lift it still higher and hold it until the nozzles had passed. The horseshoe shaped irons were attached to ordinary iron pipe, the latter serving as an attachment bar, the sizes being 1 and 2 inches. This bar was anchored to the rear end of the side plates of the truck. A brake for lifting the rakes was attached as shown in Plate XIX, and so weighted that when released it would lift the rakes.

The teeth for this lifter should be made to order. Old rake teeth were used as a trial but tempering them to secure the right shape spoiled them so that they either bent out of shape or broke off.

COST.

Changes which had to be made, trying different styles of elbows and unions, testing different sets of nozzles, together with an accident to the carrier, and the extra work required to put parts together the first time, brought the cost of this machine nearly to the $300.00 mark. At the outside the parts ought not to cost more than as follows:

Wheels	$16 00
Tank	12 00
Pump, iron triplex	85 00
Gearing and shafting	15 00
Material and building of carrier including connections to pump and tank	50 00
Material for framework and putting all the parts together	50 00
Making a total of	$228 00

A triplex bronze pump can be made to order for $40.00 additional. We believe that the actual cost of building can be reduced to $200.00.

CONCLUSIONS.

When completed and tested the machine proved much less unwieldy and awkward than appearances would indicate. It could be turned in a space of six feet, not including team. All the joints were easily packed to prevent leaking, and, the raising and lowering of the carrier in turning did not cause the horizontal telescoping joints to leak. It was thought that it would be impossible to use it in asparagus fields that were on sand beds, nevertheless a span of fourteen hundred pound horses handled it with but little extra effort on level ground where the wheels sank four inches into the sand.

Tests showed that an acre could be sprayed in less than an hour, doing the work more thoroughly than could be done by hand. Furthermore, there was a saving of material, as between 150 and 175 gals. was all that was used per acre when all the

parts worked perfectly. When many stops had to be made considerabe material was wasted as it was impossible to hold the liquid already in the arms and supply pipe.

As a whole, the machine exceeded our expectations, and in fact met all the requirements of an ideal sprayer. In building another the only changes that would be made would be in size and weight of some of the materials used.

Finally, it is not advised that any one grower should go to the expense of building such a machine to spray five or six acres of asparagus. The grower of 15 acres or over could well afford to do this. A better way would be for several growers of asparagus to combine in building such a machine; or, one person could build such a machine and do spraying for his neighbors as a business, the same as threshing is done. It is believed that a similar machine can be built for less than $200.00.

RECOMMENDATIONS.

For those who may wish to construct a similar machine, the following suggestions and recommendations are given: Possibly by the use of T iron for making the arches their weight could be reduced. We found that the cross-plates on forward truck were too light, being 2x3 in., and would recommend that the two cross-plates be made of same sized timbers as the arch-plate, namely, 3½x4½ in. We would also recommend the use of 2½x4½ in. side-plates instead of 4x4½ in. plates. These would support the weight of tank as well as the 4x4½ inch plates and reduce the weight of the truck as a whole.

The advice of the Wheel Company was taken and heavy thresher wheels used on rear axle. These were heavier than needed. The ordinary weight of wheels, such as furnished by the company for farm wagons, would have answered the purpose as well.

The advice of the Link-Belt Company was also taken regarding shafting; as a result a shaft one and fifteen-sixteenths inches

in diameter was used. This is nearly twice as heavy as required. The use of a sprocket wheel on the right rear wheel larger than that used on the Downs Power Asparagus Sprayer, and swinging a shaft, 1 in. in diameter, over the right-hand side-plate, would allow a smaller sprocket wheel on the outer end of the shaft, also a smaller one on the inner end next to the pump. In fact the latter could be small enough to be placed directly under the small sprocket-wheel on crank-shaft. In this way the pump could be placed nearer the tank, shorter chains could be used, and thus the weight of all the shafting and gearing be reduced nearly two-thirds.

The weight could be reduced slightly by placing the elbow, which follows the safety-valve, next the T and placing the safety-valve beyond the elbow.

EXPLANATION OF PLATES.

Plate XVI.—*Ground plan of power sprayer showing arrangements of parts except tool box. Drawn to scale of one-half inch to the foot.*

Plate XVII. Fig. 1.—*Ground plan of front truck.*

Fig. 2.—*Diagram of pump with connections to tank and nozzle carrier. Arrows indicate direction of flow also points of connection to other figures.*

Fig. 3.—*Diagram of one-half of carrier, rear view, showing arms.*

Fig. 4.—*Diagram of side view of arms and vertical supply pipe. All parts except arms drawn to scale of one-half inch to the foot.*

Plate XVIII.—*Rear side view of sprayer showing arrangements of parts of carrier and rakes with their supports.*

Plate XIX.—*Same as Plate XVIII with carrier elevated to show parts more plainly, especially attachment of brake bar to carrier and horizontal supports, together with anchorage to side.*

Plate XX.—*Side view of carrier and rakes elevated, side view of pump showing sprocket, also connection with shaft. In addition showing side view of arches with their braces.*

Plate XXI.—*Machine at work in field spraying two rows at a time.*

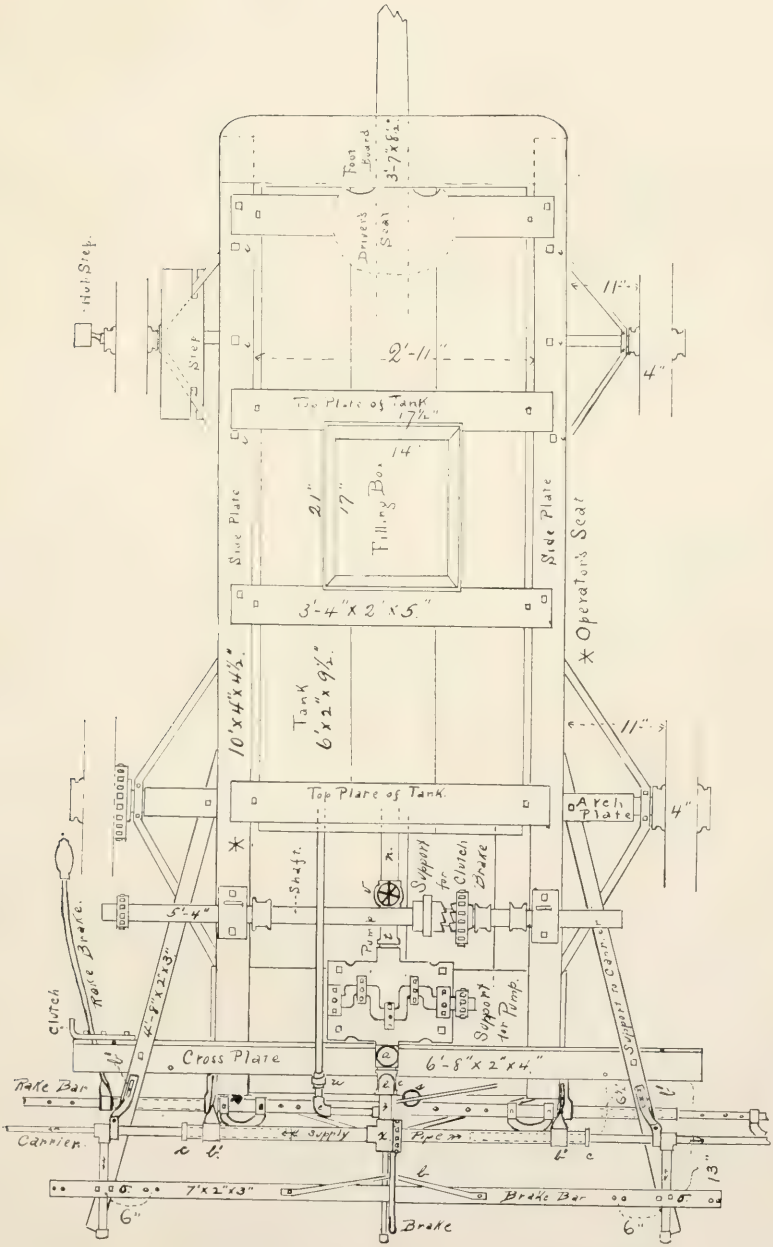

PLATE XVI.—GROUND PLAN OF ASPARAGUS SPRAYER.

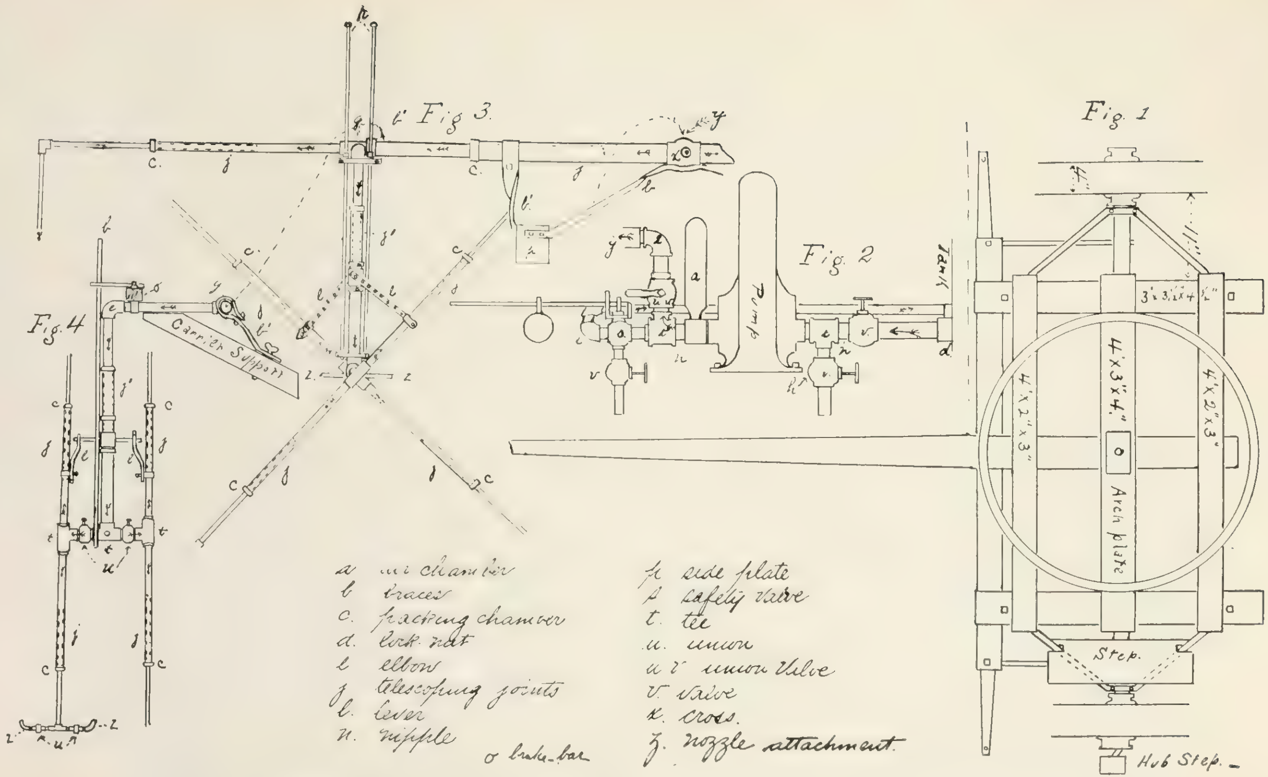

PLATE XVII.—DETAIL PLAN OF FRONT TRUCK, PUMP, CARRIER AND ARMS OF ASPARAGUS SPRAYER.

Plate XVIII.—Rear View of Sprayer.

Plate XIX.—Rear View of Sprayer, with Carrier Raised.

Plate XX.—Side View of Sprayer.

PLATE XXI.—SPRAYER AT WORK.

A FRUIT-DISEASE SURVEY OF WESTERN NEW YORK IN 1900.*

F. C. Stewart, F. M. Rolfs and F. H. Hall.

SUMMARY.

During the season of 1900 the writers made frequent visits to the orchards, vineyards and small-fruit plantations throughout Western New York for the purpose of learning what fruit diseases exist there. The information thus gathered was supplemented by the replies to a circular letter of inquiry which was sent to 200 fruit growers.

The season of 1900 being an unusually dry one, fungous diseases did not thrive. All kinds of fruit were unusually free from disease. Consequently, there are no remarkable outbreaks of disease to report. The chief feature of this report consists in descriptions of some new or little-known diseases and a few new facts about the common diseases. Such items of interest are the following: *Macrophoma* on apple (p. 174) and pear (p. 198); *Cytospora* canker of apple (p. 175); "hairy root" of apple (p. 177); a disease of apricot (p. 180); brown spot of apricot (p. 181) and peach (p. 192); a fall rust of blackberry (p. 182); hail injury to cherry (p. 186) and plum (p. 202); leaf scorch of cherry (p. 188) and pear (p. 197); frost injury to grape (p. 189); double peaches (p. 195); "little peach" (p. 191); nursery-cellar disease of peach (p. 194); *Cytospora* on peach (p. 196), plum (p. 201) and apricot (p. 181); gumming of plum fruits (p. 203); powdery mildew of quince (p. 205); cane knot of raspberry (p. 206); powdery mildew of raspberry (p. 208); and cane blight of raspberry (p. 208).

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*Reprint of Bulletin No. 191.

INTRODUCTION.

In the season of 1899 this Station, in coöperation with the Eastern New York Horticultural Society, made a fruit disease survey of the Hudson Valley. The report[1] on that work was published as Bulletin 167. Although, in some respects, the season was unfavorable for such an investigation, the results of the survey were so satisfactory that it was decided to make a similar survey of Western New York in 1900.

The two seasons' experience convinces us that the plant-disease survey, properly conducted, is profitable work for an experiment station botanist, for the following reasons: (1) It brings the station into closer acquaintance with the farmers of the State, and this is beneficial both to the farmers and to the station. (2) It brings the station officer engaged in the survey into closer acquaintance with the agriculture of the State, with its methods and its needs. Information of this nature greatly increases the efficiency of the station botanist possessing it. He learns what pathological problems most need solution and gets suggestions as to the best means of solving them. He also learns to distinguish between practical and impractical remedies. The ultimate aim of the investigator of plant diseases should be the discovery of *practical* remedies for them, and this end can not be attained unless the investigator has some knowledge of agricultural practice—the more the better. (3) The survey work familiarizes the investigator with the behavior of plant diseases in the field. Field observations serve to check up the results obtained from laboratory study. They also furnish information which is of great value in answering correspondence pertaining to plant diseases. Such correspondence is an important part of the work of a station botanist, and in order that he may answer the inquiries in the most satisfactory manner he should know what diseases occur in his State, the amount of damage usually done by them, their symptoms and how they are affected by soil, climatic, and other conditions. (4) Such a survey is certain to bring out some

[1] Stewart, F. C., & Blodgett, F. H. A Fruit-Disease Survey of the Hudson Valley in 1899. N. Y. Agr. Exp. Sta. Bul. 167.

PLATE XXII.—TERRITORY COVERED BY THE SURVEY.

new facts of importance. In the Hudson Valley survey it was discovered that the currant cane blight so destructive in the Hudson Valley is entirely different from the currant cane blight occurring in the western part of the State. In the same survey there was gathered considerable evidence to show that a destructive cane blight of the raspberry, often attributed to drought or winter injury, is in reality due to the attacks of a parasitic fungus; and the observations made in the survey of 1900 prove this beyond all doubt.

THE SURVEY: METHODS AND GENERAL RESULTS.

TERRITORY COVERED BY THE SURVEY.

The territory covered by the survey includes all that part of New York State lying west of a north and south line drawn through Lake Cayuga; namely, the Counties of Wayne, Seneca, Schuyler, Chemung, Monroe, Ontario, Yates, Steuben, Orleans, Genesee, Livingston, Wyoming, Allegany, Niagara, Erie, Cattaraugus and Chautauqua. (See Plate XXII.)

WEATHER CONDITIONS.

In Western New York the season of 1900 was excessively dry and the effects of the drought were the more prominent because the preceding season had also been an unusually dry one. The monthly precipitation for the season of 1900 is shown in the accompanying table:

Precipitation in Western New York—April to September, 1900.

Station.	April. *In.*	May. *In.*	June. *In.*	July. *In.*	August. *In.*	Sept. *In.*	Total for six months. *In.*
Romulus	.59	.60	.92	3.63	4.11	.43	10.28
Penn Yan	1.25	1.06	.78	3.91	2.36	.41	9.77
Lyons	1.19	1.85	2.74	3.46	2.49	2.01	13.74
Williamson	1.43	1.45	.86	4.09	2.91	2.56	13.30
Rochester	1.68	1.31	2.43	3.98	2.03	1.93	13.36
Scottsville	1.62	1.52	1.95	5.05	2.68	1.67	14.49
Brockport	1.78	1.42	.94	4.47	2.31	3.02	13.94
Buffalo	1.13	1.22	1.22	2.97	3.69	2.90	13.13
Westfield	.64	2.44	2.03	5.75	1.39	2.61	14.86
Avon	1.10	1.41	1.23	3.40	2.52	1.77	11.43
Akron	1.02	1.03	1.27	3.50	2.48	2.86	12.16
Atlanta	2.08	1.77	2.17	3.08	2.41	1.07	12.58

METHODS OF OBTAINING DATA.

The methods of obtaining the data were essentially the same as those employed in the fruit-disease survey of the Hudson Valley.[2] During the season the writers visited various parts of the district and made observations on the diseases of all kinds of fruit. This part of the work was done much more thoroughly than in the Hudson Valley survey, and, naturally the vicinity of Geneva was more thoroughly explored than any other part of the district. At the close of the season a circular letter of inquiry was sent to 200 fruit growers in Western New York. This letter requested information as to the amount of damage done by the common fruit diseases in the season of 1900 and was similar to the one sent to Hudson Valley fruit growers[3] in 1899. Eighty-four replies were received.

MAGNITUDE OF THE FRUIT INDUSTRY

Western New York is famous as a fruit-growing section. With regard to the quantity and variety of high-grade fruit grown it is unequaled by any other section of equal area in the United States. The most important fruit-growing Counties are those bordering on the Great Lakes, namely, Wayne, Monroe, Orleans and Niagara on Lake Ontario; and Chautauqua on Lake Erie. The fruit industry is also large in the Counties of Seneca, Schuyler, Ontario, Yates, Livingston, Genesee and portions of Erie; while in Cattaraugus, Allegany, Steuben and Chemung Counties it is comparatively unimportant.

The fruits grown extensively are apples, blackberries, cherries, currants, grapes, peaches, pears. plums, quinces, raspberries, and strawberries. There are many commercial plantations of gooseberries and several of dewberries. Apricots are also grown to some extent. The largest and best orchard of apricots east of the Rocky Mountains is located near Lodi on the east shore of Seneca Lake.

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[2] L. c., p. 280.

[3] L. c., p. 281.

The nursery business, also, is very large in Western New York. It is especially prominent in the vicinity of Rochester, Geneva and Dansville. Several thousands of acres are devoted to the growing of nursery stock.

GENERAL STATEMENT OF RESULTS.

On account of the drought most fruit diseases were probably much less destructive than usual. In many cases the expense of spraying was wholly wasted because there was nothing to spray for. Many localities were practically exempt from the common fruit diseases which are ordinarily very destructive. In some other localities, however, certain of these diseases caused much damage. These variations were due to differences in local conditions, chiefly rainfall. So far as its influence on fungous diseases is concerned the total amount of rainfall is not nearly so important as the manner of its distribution. Frequent, light showers are more favorable to the growth of parasitic fungi than heavy showers at long intervals.

It will be observed that the accounts of several of the diseases discussed in this bulletin are very incomplete. We met with many puzzling things upon which we were unable to make sufficient observations for want of time. The field was entirely too large to be covered thoroughly in a single season. Still we think it best to publish these observations even though they be fragmentary. They at least furnish suggestions for further study.

APPLE DISEASES.[4]

The heavy gale of September 12 blew off large quantities of apples. In many orchards from 25 to 50 per ct. of the fruit fell. So far as the apple crop is concerned this wind was by far the greatest disaster of the season. No disease has caused widespread destruction; in fact, no disease has been at all conspicuous except in a few localities.

SCAB (*Fusicladium dendriticum* (Wallr.) Fckl.).—This has done very little damage. We have observed no orchard in which it has caused sufficient injury to warrant the expense of spraying.

[4] In this bulletin no account is taken of damage caused by insects.

The majority of our correspondents report little or no scab, but one at Castile, Wyoming Co., says that scab destroyed 50 per ct. of the unsprayed fruit in that locality, and at Silver Creek, Chautauqua Co., Greenings are reported to have been practically all scabby. A correspondent at Fredonia reports it to have done considerable damage there, but not as much as usual.

LEAF SPOT.—This is a name which may be applied to any one of several diseases and insect injuries. It is most commonly used to designate the circular, dead, brown spots caused by two species of fungi belonging to the genus *Phyllosticta*. We have observed only traces of the *Phyllosticta* leaf spot. Several correspondents report some damage from leaf spot, but we have no means of determining the exact nature of the disease to which they refer. Some of it was probably due to injury from arsenical spraying mixtures, some was probably wind injury, and a few persons who reported the occurrence of leaf spot probably referred to scab on the leaves. Some do not understand that scab attacks the foliage and twigs as well as the fruit..

FRUIT SPOT.—In our circular we asked for information about the occurrence of "sunken, brown spots on the fruit." We referred to the fruit-spot disease in which small pockets of dry, corky tissue occur beneath the skin of the fruit, also scattered all through it later in the season. This disease is quite well known to our fruit growers. The reports indicate that it has been somewhat less prevalent than usual. It has occurred sparingly all over the district, but nowhere very destructively. A correspondent at Pavilion, Genesee Co., reports it "very bad on large Baldwins"; one at Ransomville, Niagara Co., "ten per ct. in some orchards"; one at Gorham, Ontario Co., "eight per ct." The varieties mentioned as being especially subject to the disease this season are Baldwin, Northern Spy and Rhode Island Greening. It seems to be the general opinion that large specimens are more affected than small ones of the same variety.

The exact cause of this fruit-spot disease is unknown,[5] but it

[5] For a good summary of our knowledge of the disease see Jones, L. R. Brown Spot of the Apple. Twelfth Ann. Rept. Vt. Agr. Exp. Sta., pp. 159–164.

is safe to say that it is *not* due to any parasitic organism and consequently it is difficult to understand how spraying can have any effect upon it. Nevertheless, successful results from spraying with Bordeaux mixture have been reported by Lamson[6] and a correspondent at Spencerport reports concerning the disease, "about as usual except where liberally sprayed with Bordeaux mixture nearly exempt." Wortmann[7] and Zschokke,[8] two European investigators, believe the spots to result in some way from the loss of water from the affected parts.

TWIG BLIGHT OR FIRE BLIGHT (*Bacillus amylovorus* (Burr.) De Toni).—This disease has been scarce. At Ripley, Chautauqua Co., we saw a bearing tree with many dead twigs; at Vine Valley, Yates Co., a few trees of different varieties were considerably injured by it; and in a nursery at Orleans, Ontario Co., it killed a few trees. Only six correspondents mention the disease at all and of these but one (Bluff Point, Yates Co.) reports it doing serious damage.

HOW THE FRUIT IS KEEPING.—This question was answered by 64 persons, 20 of whom report apples keeping well; 21 fairly well and 15 poorly. Four expressed the opinion that apples ripened prematurely, while the remaining four gave the following answers: "Baldwins good, Greenings poor;" "Baldwins very well; King, Spy and Greening not very well;" "Baldwins look well; Spys are not keeping well." From these reports it appears that up to December 1, the time the reports were made, the apple crop as a whole was in about average condition.

As we have made no investigation of stored fruit we are unable to state what fungi have been chiefly concerned in the rotting of apples this season. Bitter rot, *Glœosporium fructigenum*, is reported to have been unusually common.

[6] Lamson, H. H. N. H. Agr. Exp. Sta. Buls. 45 and 46.

[7] Wortmann, Jul. Ueber die sogenannten "Stippen" der Aepfel. *Landw. Jahrb.*, 21: 663–675.

[8] Zschokke, A. Stippigwerden der Aepfel. *Landw. Jahrb. d. Schweiz.*, 11: 192.

CANKER (*Sphæropsis malorum* Pk.)—Canker[9] on the limbs and trunks of apple trees is common throughout the whole district. From the nature of the disease it is difficult to determine whether it has increased or decreased in virulence during 1900. The fungus causing canker is also the cause of the black rot of the fruit, and what appears to be the same fungus sometimes attacks the leaves. We have searched carefully for it on both fruit and leaves in many orchards where canker was abundant. Occasionally we have found it attacking fruit still hanging on the tree but the damage it does there is insignificant; its worst effects are seen among stored fruit. We have failed to find the fungus on apple leaves anywhere in Western New York.[10]

We have also sought for Cordley's[11] apple-tree anthracnose fungus, *Glœosporium malicorticis*, but failed to find it.

MACROPHOMA CANKER.—On May 10, we observed that the bark on some cankered apple limbs in the Station orchard was thickly covered with conspicuous creamy-white specks of pinhead size. Upon microscopic examination these white specks proved to be masses of the exuded spores of *Macrophoma malorum* (Berk.) Berl. & Vogl. May 12 the same thing was observed in abundance at Waterloo; May 16 at Dresden and Phelps; May 23 at Barker; and May 24 at Hilton. It is plain that the exudation of *Macrophoma* spores on apple limbs during May was a common occurrence. As a rule, the exudation was noticeably more abundant on the side of the limb not exposed to the sun. At Geneva the weather conditions preceding the exudation of spores were as follows: For about a week prior to May 7 the weather was cold and dry. During the night of May 7 there was a heavy rain. May 8 was very warm and with a light rain at night. May 9 was cloudy, damp and cold, becoming clear and colder at night.

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[9] For a full discussion of apple-tree canker see Buls. 163 and 185 of this Station.

[10] We have, however, collected it on apple leaves at Bayside, Long Island, during the past season.

[11] Cordley, A. B. Some Preliminary Notes on Apple-Tree Anthracnose. Oreg. Agr. Exp. Sta., Bul. 60.

Even where the *Macrophoma* spore masses were not outwardly conspicuous it was often found that just beneath the loose outer bark, which peels off readily, there was an abundance of white spores and mycelium.

The *Macrophoma* was found associated with all stages of the canker (but not constantly), even with the very beginning of the canker where it was often the only fungus to be found. Small, dead, sharply delimited areas of bark one inch in diameter frequently showed multitudes of the exuded spore masses and nothing else.

Since the spores of *Macrophoma malorum* are about the size and shape of the spores of *Sphæropsis malorum* Pk. and differ from them only in being uncolored, the opinion has been advanced that the former is only an immature stage of the latter; but we believe that the two forms are distinct species. It is true that immature *Sphæropsis* spores are uncolored, but the colorless stage is quickly passed and when full grown they are generally colored; whereas the *Macrophoma* spores remain uncolored indefinitely after attaining full size. The fact of their expulsion in May is evidence of their maturity at that time, but they show no color. Moreover, Paddock[12] has seen the hyaline spores germinate so there can no longer be any doubt that the *Macrophoma* is distinct from *Sphæropsis malorum*.

It appears to us that *Macrophoma malorum* is parasitic upon apple bark, but Paddock's[13] inoculations gave only negative results. If it is a parasite the lesions formed by it are very similar to those of *Sphæropsis*.

CYTOSPORA CANKER.—About the middle of May Mr. Paddock called our attention to dead patches of bark on several apple trees in the Station orchard and pointed out the fact that while the dead areas resembled those produced in the early stage of *Sphæropsis* canker, they were, nevertheless, slightly different and were inhabited by a different fungus which proved to be a species of *Cytospora*. The affected patches were discolored,

[12] Paddock, W. Bul. 185 of this Station, p. 212.

[13] L. c.

sharply defined and of various sizes from one-half inch to three inches or more in diameter and often coalesced to form large areas.

These areas occurred on all sides of the limbs, and branches were frequently killed outright. On the larger branches only the outer layer of bark was dead. Scattered all over the dead areas were *Cytospora* pycnidia filled with multitudes of small, colorless spores and, generally, no other fungus was present. The *Cytospora* appears to be parasitic, but positive proof is lacking.

When the subject of apple canker as it occurs in New York State is thoroughly understood we believe it will be found that there are at least three distinct diseases, which although strikingly similar in their gross characters are yet sufficiently different to make it possible for an expert to distinguish them without the aid of a microscope. Of the three kinds of canker the *Sphæropsis* canker is undoubtedly the most important and the *Cytospora* canker the least important.

CROWN GALL.—So far as the apple is concerned, crown gall is confined chiefly to the young trees in the nursery. In this disease rough, spongy, roundish galls occur on the roots. They are usually found at the crown, but may occur on any part of the root system. They are of all sizes up to that of a fist. The nature of crown gall is not well understood. According to Toumey[14] similar galls occurring on the roots of the almond in Arizona are caused by a slime-mold closely related to the fungus which causes the club-root disease of cabbage and allied plants. Crown gall should not be confused with apple-root galls caused by the woolly aphis. Woolly aphis galls are smaller, smooth, hard and generally elongated rather than round.

We find crown gall not uncommon on apple trees in the nurseries in Western New York, but we know of no case where it has caused material loss. Usually nurserymen discard the worst affected trees. We would recommend that all trees show-

[14] Toumey, J. W. An Inquiry into the Cause and Nature of Crown Gall. Arizona Agr. Exp. Sta., Bul. 33.

Plate XXIII.—"Hairy-Root" of Apple.

ing the least trace of the disease be rejected; for, although we have never seen any ill effects from the planting of affected apple trees, it appears probable that the disease may thus be spread to other fruits like peaches and red raspberries which are sometimes much injured by it.

A nurseryman in Wayne Co. writes as follows: "Two years ago we planted a row of apple trees affected with crown gall beside a row of healthy trees. This fall we dug up a number of the trees and some had galls on them and some had not. The trees with the crown gall made just as good a growth as the healthy trees near by, the root system seemed to be healthy and supplying the top with all the nourishment needed for a strong growth."

"HAIRY ROOT."—While examining nurseries for crown gall we came across a nursery trouble of apple trees which nurserymen call "hairy root." Affected trees have few, if any, large branch roots. The root system consists of a multitude of very small roots which spring in rosettes from the somewhat thickened main root, giving it a bushy or hairy appearance. (See Plate XXIII.) Affected trees are worthless for planting.

One nurseryman tells us that he has known this trouble for 50 years; another has known it 40 years; and it appears that many nurserymen are more or less acquainted with it. Yet we have never seen any published account of such an apple disease. While specimens of it are occasionally found in the majority of the nurseries in Western New York, we have not heard of any nursery where it is sufficiently abundant to cause appreciable loss. Perhaps, one tree in each 500 may be affected with "hairy root." Nurserymen are pretty generally agreed that the disease shows itself on the seedlings and is much more common among Western-grown seedlings than among home-grown ones. The affected seedlings are usually rejected at the grafting bench, but some are passed only to be discarded later when the trees are dug for market.

A tree affected with "hairy root" may at the same time suffer from attacks of woolly aphis or crown gall or both, but in the

majority of cases neither of the latter two diseases is present, showing that "hairy root" is a distinct disease. Some think it a consequence of grafting, but this can not be true because it occurs on budded trees as well as on grafted ones. Some believe that it is more common on light soils while others say that the character of the soil makes no difference. It seems to be confined to the apple. The cause is unknown.

HAIL INJURY.—In the summer of 1898 a severe hailstorm passed over the orchards south of Geneva. While making some observations on fruit trees in that locality in April, 1900, we observed some interesting hail effects which were still visible on the bark. The details of these observations are given in the discussion of plum diseases (page 202) and cherry diseases (page 186). On apple bark the only outward evidence of hail injury was the presence of a few scars where the bark had been broken by hailstones; but upon removing the outer layer of bark numerous brown, corky spots were revealed. The location of these dead spots was not indicated externally by any differences of color in the outer bark as on the plum and cherry.

POWDERY MILDEW (*Podosphæra oxyacanthæ* (D C.) D By.).—This is often very troublesome to apple seedlings in the nurseries of Western New York; so much so, in fact, that spraying with Bordeaux mixture to prevent mildew is one of the necessary operations in the growing of apple seedlings. However, in 1900 this disease appears to have been almost entirely absent. We have neither seen nor heard of its occurrence except in a nursery at Orleans, Ontario Co., where traces of it were observed upon many plants.

We have been unable to take a single specimen of *Sphærotheca mali*.

RUST (*Gymnosporangium* spp.)—We have been constantly on the lookout for this disease, but have met with it only at Dresden, where we found a few trees showing a little rust on August 28.

RUSSETING OF FRUIT.—There has also been very little of this trouble.

WINTER INJURY AND THE KING DISEASE.—In the apple orchards throughout Western New York one frequently comes across trees on which the bark around the base of the trunk is dead or loose or perhaps already fallen away, leaving the wood exposed for a distance of one or two feet above the surface of the ground. Sometimes the injury extends clear up to the crotch and into the larger branches. This disease attacks several varieties, but is especially troublesome to the Tompkins' King, or King as it is commonly called. This variety is so susceptible to attack that the disease is generally known as the "King disease," and the planting of the King in recent years has considerably fallen off on account of it. The cause is unknown; and our recent observations have thrown little new light on the subject. That injury of this sort is sometimes winter injury there is little doubt. The following case was evidently of that nature: In April, 1899, we examined, at Hall's Corners, an orchard which was 25 years of age and contained several different varieties. For the most part the trees were in good condition, but in a row of Baldwins, at about the center of the orchard, there were ten trees with patches of bare wood extending from 12 to 18 inches above the surface of the soil. While the injuries were commonly on the southwest side they were not confined to that side, but occurred on all sides. On two trees the injury extended clear around the trunk, but was bridged over by several strips of living bark. Bridges of living bark were also observed on some of the other affected trees. The margins of the wounds were nicely healed over. The trouble was first noticed in the spring of 1897 when the bark became loosened.

OTHER DISEASES.—*Monilia fructigena* has been occasionally found rotting fruit on the trees. We have not met with water core,[15] core rot,[16] or Atkinson's œdema.[17]

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[15] Cobb, N. A. Water Core in Apples. *Agr. Gaz. N. S. Wales*, 2: 286–287, 1891.

[16] Craig, J. Core Rot of Apples and Pears. Can. Exp. Farms Rept., 1896: 172–173.

[17] Atkinson, G. F. Œdema of Apple Trees. Cornell Exp. Sta., Bul. 61: 299–302.

APRICOT DISEASES.

COLLAR ROT.—The most destructive apricot disease which we have come across is a disease of the trunk which may be called collar rot or dying at the collar. A large apricot orchard at Sodus has been ruined by it. This orchard was planted in 1890 with apricots budded on apricot stocks. In each subsequent season some of the trees have died, and the others have made a stunted growth. The dead trees were replaced by others budded on *Prunus simoni* stocks. Many of these also died and then trees on *Prunus mariana* stocks were tried with no better results, and at the present time the orchard is practically worthless.

We became acquainted with the orchard in 1899. In May of that year we made a careful examination of the affected trees and found the seat of the trouble located just below the surface of the ground at the point where the bud was originally inserted, which is called the union or collar. For a distance of three or four inches above the union the bark was dead and brown entirely around the trunk. On trees recently dead the injury never extended below the union and often there was a sharp line of demarcation between the living bark of the stock and the dead bark of the trunk; but on trees which had been dead for some time the bark of the stock also turned brown and it was not so plain that the trouble had started at the union.

As a rule, the affected trees wilt rather suddenly some time in early summer after having put out their leaves in an apparently normal manner. The trouble is not confined to any particular part of the orchard; dead trees are intermingled with living ones. Only a few of the trees have made a fair growth. The majority of the living trees have gnarly, stunted branches bearing large and prominent lenticels which make the bark very rough to the touch. The lenticels somewhat resemble the *Cytospora* pycnidia discussed below.

We are unable to account satisfactorily for this apricot trouble. Neither insects nor fungi seem to be the cause of it.

The orchard contains quite a variety of soils and yet the disease is equally destructive in all parts; so it does not seem to be wholly a question of soil. We should suspect the trouble due to imperfect union of stock and bud were it not for the fact that some trees of the same lot were planted at Lodi and have there done well. Perhaps it is brought about by the combined effect of uncongenial soil, uncongenial climate and imperfect union.

TRUNK AND BRANCH INJURY.—In Bulletin 167, page 286, we described an apricot trunk disease found in the Hudson Valley. A similar disease has been observed at Lodi and Geneva. At Lodi vigorous trees in full foliage suddenly wilted and died early in June. At the surface of the soil the bark on the southwest side of the trunk was dead and shrunken to the wood.

In the Station orchard two trees of Japanese apricot, variety Bongoume, show several large areas on trunk and larger branches on which the bark is dead and shrunken to the wood. The dead areas bear numerous pycnidia of *Cytospora*.[18]

At Lodi we saw large, vigorous apricot trees, some of the larger branches of which were dying. The only apparent cause was *Cytospora* which was growing profusely on the bases of the dying branches, thickly covering them with its pycnidia. It is our opinion, that in this case at least, the *Cytospora* was parasitic.

BROWN SPOT (*Helminthosporium carpophilum* Lév.)—We have occasionally seen this disease at Geneva and Lodi during the past two seasons. It attacks the fruit, producing cinnamon-brown, slightly-elevated spots which have a reddish tinge when young. The apricot disease described and figured by Bailey[19] was probably brown spot. For a further discussion of brown spot see page 192.

OTHER DISEASES.—There has been some fruit rot caused by *Monilia fructigena*, but much less than usual. We have seen no black spot of the fruit, *Cladosporium carpophilum*, no powdery mildew and no leaf spot of any kind.

[18] For a discussion of the *Cytospora* on stone fruits, see page 323.

[19] Bailey, L. H. Apricot Growing in Western New York. Cornell Univ. Exp. Sta. Bul. 71 : 277.

BLACKBERRY DISEASES.

CANES BROKEN BY SNOW.—A good many blackberry canes were broken by the heavy snow which fell about March 1, 1900; but the loss from this cause was not nearly so great as fruit growers feared it would be.

ORANGE RUST (*Puccinia peckiana* Howe. Syn. *Cæoma nitens* Schw.)—The blackberry rust so often mentioned in the economic literature of plant diseases in this country is the orange rust, *Cæoma nitens*, which is believed to be the æcidial stage of *Puccinia peckiana*. This is a common and destructive rust which is well known to fruit growers. During the past year we have frequently observed it on blackberries, sometimes doing much damage. The reduction of prickles on rusted canes was found to be less common than in the Hudson Valley. In Chautauqua County at Ripley, Portland and Fredonia the rust was parasitized by the fungus *Tuberculina persicina* (Ditm.) Sacc. The large dark-purple fruit bodies of the *Tuberculina* were abundant on the under surface of the leaves. Where the parasite is present the rusted plants are much less conspicuous because there is less of the orange-colored powder. Spore production is greatly checked by the parasite.

Orange rust appears only in spring, runs its course and disappears by July; hence it may be called *spring* rust. To be sure, it has a fall form, the teleutospore form which is called *Puccinia peckiana;* but this is not common and moreover it is so inconspicuous that it is rarely observed except by experts who are searching for it. We have not observed it on blackberries the past season.

YELLOW FALL RUST (*Uredo mülleri* Schroet.)—Besides the orange rust above mentioned, mycologists recognize several other rusts of blackberries; but, heretofore, only one other rust has been reported as occurring in abundance on cultivated blackberries. We refer to *Chrysomyxa albida* Kühn, which is called white rust because of the pale yellow color of its spores. Stone & Smith[20] have reported the occurrence of white rust on culti-

[20] Stone, G. E. & Smith, R. E. Ninth Ann. Rep. Mass. (Hatch) Exp. Sta., p. 74.

PLATE XXIV.—1, BARREL-SHAPED ENLARGEMENT ON CHERRY; 2, NORMAL PEACH AND "LITTLE PEACHES" OF SAME VARIETY AND AGE; 3, YELLOW FALL RUST OF BLACKBERRY (NATURAL SIZE).

vated blackberries in Massachusetts. We have sought for it in Western New York during the past season, but have found only traces of it.

We have now to report the occurrence of a *third* blackberry rust which we will call yellow fall rust to distinguish it from the other two blackberry rusts. On May 28 while examining a plantation of blackberries near Oaks Corners, we found several canes bearing rust sori which were bright yellow, 3–10 millimeters long, conspicuous and located chiefly near the surface of the ground although some occurred well up on the canes. They proved to be uredo sori and contained multitudes of yellow spores which were roundish or often somewhat angular, slightly roughened with minute projections, and had a diameter of 23–24 μ. There were no paraphyses.

The variety of blackberry affected was Agawam. At this time there was no rust on the leaves except on three or four plants affected with orange rust; but the owner informed us that every fall the leaves were covered with a yellow rust.

May 29 the same rust was found on canes of wild blackberries at Geneva and on June 13 on wild blackberries at Williamson.

The next visit to the Oaks Corners plantation was on August 15. Over a large portion of it, also in parts of two other plantations on the same farm, the plants were covered with a conspicuous bright yellow rust which appeared chiefly on the under side of the leaves. (See Plate XXIV, Fig. 3.) It was most plentiful on leaves of fruiting canes, but also occurred sparingly on leaves of young canes. About a month later the rust was quite as abundant on the leaves of new canes as on the leaves of old ones. At this later date it was also observed on the fruit pedicels and bracts and occasionally on the sepals; and was more frequently found on the upper surface of the leaves than it had been in August.

The rust on the leaves was the same as that found on the canes in May. Throughout the season we watched for the appearance of teleutospores which would assist in the determination of the species of the rust, but without avail. The only

teleutospores found were a few belonging to *Chrysomyxa albida*. We were finally obliged to refer the rust to Dr. W. G. Farlow, who informs us that it is *Uredo mülleri* Schroet. It is known only in the uredo stage.

This rust was very abundant in three large plantations, all on one farm, but we have not seen it anywhere else on cultivated blackberries except at the Station where perhaps half a dozen leaves were affected by it. In the plantation in which the rust was first discovered and where it was most abundant there are two kinds of soil—light sandy soil and sandy loam. On the former, almost every leaf was affected; while on the latter the plants were practically free from rust until in September, and even then they were very much less rusted than plants in the sandy soil. In one of the other plantations the rust was most abundant on a sandy knoll. It is plain that it has a preference for plants in sandy soil.[21]

There is no cause for alarm at the appearance of this blackberry rust. It is not new but simply an unusual outbreak of a fungus which has long been known to attack blackberries occasionally. In case it should become abundant it is improbable that it would cause much damage. The owner of the affected plants says that they have been yellow with the rust every fall for several years, but it does not seem to injure them. It appears too late in the season to do much damage.

LEAF SPOT (*Septoria rubi* Westd.).—Leaf spot has been of quite common occurrence on blackberries, but we doubt if it has done any material damage to them. It was observed that on different varieties the fungus may produce quite different spots. On some varieties the spots are light brown, while on others they are dark brown. Sometimes these differences are so marked that at first we suspected that the two kinds of spots were caused by different fungi, but we found only *Septoria rubi* upon them.

[21] Stone & Smith (Twelfth Ann. Rep. Mass. (Hatch) Exp. Sta., pp. 61–73) have observed that the same is true of asparagus rust.

CANE KNOT.—We have sought for Bailey's[22] cane knot of blackberry but have not found it. Among wild blackberries we have found cane knots caused by an insect. A few inches above the ground the canes bore swellings from one to two inches in length and having a diameter about one-half greater than normal. The swellings were mostly smooth but some were cracked owing to the canes having broken over at that point; and a few specimens collected at Barker showed eruptions of soft, spongy tissue. Inside the swellings there were the whitish larvæ of the gouty gall-beetle, *Agrilus ruficollis*. These larvæ were boring in the pith. In many cases they had also girdled the cane by boring around it just under the bark. Undoubtedly, the larvæ were the cause of the swellings. These observations were made in May.

On the Station grounds we have observed enlargements on blackberry canes near the ground which were due to mechanical injuries made by tools used in cultivation.

OTHER DISEASES.—At Portland a powdery mildew was observed on a few canes of the variety Snyder. It was probably the same fungus as that found on black raspberries (see page 208). As in the case of the raspberry, only rusted plants were attacked.

Anthracnose, *Glœosporium venetum*, has done very little damage to blackberries.

Crown gall or root knot occasionally attacks blackberries, but is rarely destructive to them.

CHERRY DISEASES.

FRUIT ROT (*Monilia fructigena* P.).—On account of the extremely dry season the loss from fruit rot has been much less than usual. A few correspondents report losses of 15 to 20 per ct.

BLACK KNOT (*Plowrightia morbosa* (Schw.) Sacc.).—Black knot attacks sour cherries in Western New York, but is easily kept

[22] Bailey, L. H. Blackberries. Cornell Univ. Agr. Exp. Sta. Bul. 99: 427–428. Illus.

under control by cutting out and burning the knots. It is much less destructive to the cherry than to the plum. Probably the disease has spread less than usual during the past season. We have sought for it on the wild black cherry, *Prunus serotina*, but have failed to find it on that host in Western New York.

LEAF BLIGHT (*Cylindrosporium padi* Karst.).—Leaf blight has given very little trouble either to bearing trees or to nursery stock. In the nurseries of Western New York cherry seedlings, especially those of the Mazzard type, often suffer severely from leaf blight, but in 1900 cherry foliage was generally quite perfect.

WITCHES' BROOMS (*Exoascus cerasi* (Fckl.) Sadeb.)—This fungus is now known to occur on the cultivated cherry in three localities in Western New York; viz., at Sodus Center in Wayne County, Appleton in Niagara County, and Elba in Genesee County. In each case it was found only on a single tree. Other places in New York where it is known to exist are Athens, West Athens and Catskill (all in Greene County) and various places on Long Island. It is not likely to become troublesome.

HAIL INJURY.—Hailstones too small to break the bark may bruise it in such a way as to cause the formation of brown, corky spots within the bark. Many such spots are indicated externally by the lighter color of the outer bark which may also be slightly elevated; but many others are revealed only when the outer layer of bark is removed. We have observed such hail injury to cherries at Geneva. (See Hail injury to plum, page 202.)

LEAF SCORCH.—Although the season of 1900 was drier than that of 1899 there was none of the cherry leaf scorch such as occurred in 1899. We have watched the Maxwell cherry orchard which was so severely affected by leaf scorch in 1899[23] to determine the effect upon the crop of 1900. This orchard contained 715 11-year-old Montmorency trees. About the middle of August, 1899, 75 to 85 per ct. of the foliage on 637 of these trees was killed by leaf scorch; and on 57 more 50 per ct. of

[23] See Bul. 162 of this Station, pp. 172–175.

the foliage was killed. In 1900 our first observations were made May 10. At that date the flower buds were unopened and only a few leaf buds broken, but it was even then evident that the trees were considerably injured. On many branches the majority of the buds were dead. The wood of the preceding year's growth was frequently dead, or, if living, was badly discolored. Further observations were made May 21, when the trees were in bloom. Many flower buds failed to open; those which did open were belated, the flower pedicels were quite generally shortened and a large percentage failed to set fruit. We are informed that there was a light crop of fruit.

In an orchard at Hector the leaf scorch in 1899 affected only the south half of each tree. In the spring of 1900 we found that the flower pedicels on the south side of these trees were abnormally short, the flowers often being almost sessile; while on the north side they were considerably longer and nearly normal.

A NEW FUNGUS ON CHERRY BRANCHES (*Cryptosporium cerasinum* Pk.).—In the vicinity of Geneva dead cherry branches are frequently infested by a species of *Cryptosporium*. Specimens were submitted to Prof. C. H. Peck, who informs us that the fungus is an undescribed one and that he proposes to call it *C. cerasinum*. It is probably not parasitic. Its spores resemble those of the cherry leaf-blight fungus, *Cylindrosporium padi*.

ENLARGEMENTS ON THE BRANCHES.—Occasionally cherry branches show barrel-shaped enlargements of various sizes. On the Station grounds there is a Chinese double-flowering cherry which is seriously affected in this way. The enlargements are numerous on all branches more than three years of age, and occur even on the trunk. One branch four feet long bears nine enlargements. They are produced by an abnormal thickening of the bark which is dead and brown and often deeply scarred by wide, rough longitudinal slits. (See Plate XXIV, Fig. 1). The cause of the enlargements is unknown to us.

OTHER DISEASES.—There has been a little powdery mildew, *Podosphæra oxyacanthæ*, on nursery stock and occasionally on the tips of twigs on bearing trees; but it has not been destructive.

Crown gall is quite common on cherry trees in the nursery.

We have not taken a single specimen of scab, *Cladosporium carpophilum*, or of rust, *Puccinia pruni.*

CURRANT DISEASES.

CANE BLIGHT.—This disease is of frequent occurrence in the currant plantations in Western New York, but not nearly so destructive there as it is in the Hudson Valley. In Western New York the fungus *Nectria cinnabarina* is commonly associated with the disease although we have also sometimes found the sterile fungus which is the chief cause of the currant cane blight in the Hudson Valley. We observe that in Western New York the disease generally attacks the plants near the surface of the ground, making it difficult to apply successfully the preventive measure of pruning out the affected branches as has been suggested[24] for the Hudson Valley.

LEAF SPOT.—We have observed three kinds of currant leaf spot; viz., leaf spot caused by *Septoria ribis*, by *Glœosporium ribis* and by the four-lined leaf-bug. The *Septoria* leaf spot has been the most common, but it has not done much damage.

POWDERY MILDEW (*Sphærotheca mors-uvæ* (Schw.) B. & C.).—The powdery mildew of the gooseberry sometimes attacks currants. At Ripley, Chautauqua County, we saw this mildew in two plantations of currants. In one case the plants were unusually thrifty and growing in a plum orchard. On many plants the mildew attacked the leaves at the ends of the canes, and on a few plants it also attacked the berries, covering them with a brown felt-like growth.

GOOSEBERRY DISEASES.

POWDERY MILDEW (*Sphærotheca mors-uvæ* (Schw.) B. & C.).—The only important disease affecting gooseberries in 1900 was powdery mildew, which, as usual, caused much damage. In many instances the entire crop of certain varieties was ruined by it. The English varieties suffer most, but some American varieties are also subject to it.

[24] Bul. 167 this Station, p. 294.

GRAPE DISEASES.

Diseases in General.—Vineyards were remarkably free from disease. Black rot (*Læstadia bidwellii*) and downy mildew (*Plasmopara viticola*) were destructive only in a few localities. Powdery mildew (*Uncinula necator*) and anthracnose (*Sphaceloma ampelinum*) were rare. A few severe cases of "shelling" were reported, but this trouble was not at all common. Black knot (black, warty enlargements of the stem due to frost injury) is less common than we supposed. Occasional specimens may be found in many vineyards, but it is rarely of sufficient abundance to cause material loss.

Russeted Fruit and Protruding Seeds.—In various localities in Western New York the green grapes showed russet bands and blotches which were only skin deep. Their appearance was very suggestive of the russeting of apples and pears and we think it due to the same cause, weather conditions,—probably a light freeze after the fruit was set. On many of the russeted fruits one or more seeds were exposed and sometimes prominently protruded. In some cases seeds were exposed on fruits which were not russeted. Nevertheless, we believe the russeting and exposure of seeds both due to the same cause.

PEACH DISEASES.

Leaf Curl (*Exoascus deformans* (Berk.) Fckl.).—Leaf curl has done but little damage. A few correspondents report considerable loss from it, but in general it appeared only on particularly susceptible varieties such as Elberta.

It is now known that this destructive disease may be almost wholly prevented by a single thorough spraying with Bordeaux mixture in late winter or early spring *before the buds break.* Applications made after the foliage has appeared have little or no effect. By the time the leaf buds begin to show green it is already too late to spray. At Williamson we saw an Elberta orchard which had been well sprayed on April 30, at which time some of the buds were breaking. Leaf curl was quite as bad on

EXPLANATION OF PLATE XXV.

FIG. 1.—*Peach twigs bearing the knots on which* Helminthosporium *spores are found.*

FIG. 2.—*A peach affected with brown spot caused by* Helminthosporium carpophilum *Lév.*

FIG. 3.—*Two* Helminthosporium *spores direct from a peach twig killed by the fungus. They represent the prevailing forms.*

FIG. 4.—*Two spores of* H. carpophilum *from peach fruit. They represent the prevailing forms found on the fruit.*

FIG. 5.—*Five spores of* Helminthosporium *grown in a pure culture obtained from the knots shown in Fig.* 1.

FIG. 6.—*A spore from the same culture germinated in sugar solution. The normal method of germination.*

FIG. 7.—*Three spores from the same culture germinated in distilled water. Abnormal germination.*

FIG. 8.—*Mycelium and four newly formed spores grown in sugar solution.*

Figures 3–8 *were drawn with the aid of a camera-lucida and all to the same scale.*

PLATE XXV.—GROSS AND MICROSCOPIC CHARACTERS OF PEACH BROWN SPOT FUNGUS.

these sprayed trees as it was on any unsprayed trees in the neighborhood. The spraying had been done a little too late.

FRUIT ROT (*Monilia fructigena* P.).—Fruit rot was not destructive to medium and late varieties; but on some early varieties such as Alexander and Early Rivers it not only destroyed a large proportion of the fruit, but also commonly attacked the branches, killing them back from six inches to two feet.

"LITTLE PEACH."—In different parts of the State large quantities of peaches were so small that they were not gathered. Such peaches were most plentiful in Niagara County where the peach growers believe that they have the genuine Michigan "little peach" disease and are much alarmed over it. Some large orchards in that county have been ruined by a disease presenting all the symptoms described by Dr. Smith[25] and we have no doubt that it is the same disease as the one which has lately attracted so much attention in Michigan. According to the testimony of fruit growers the disease has existed in Niagara County for at least six, and probably eight, years. It has also been known for six years in Monroe County. The "little peach" disease is often confused with the effects of overbearing and drought which sometimes appear to produce identically the same symptoms. So far as we can see there is no difference between the two except that trees affected with "little peach" are said never to recover from it, while the ill-effects of overbearing may pass away. In some cases the small size of the fruit is probably the combined effect of disease, overbearing and drought. A very large proportion of the so-called "little peaches" in New York in 1900 resulted from overbearing and drought and might have been prevented by vigorous thinning.

YELLOWS.—Peach yellows is prevalent in Western New York and although it is an old trouble there are still many fruit growers who do not know the disease. All trees having yellow foliage are not affected with yellows. Borers in the trunk, lack of cultivation, lack of food, etc., often cause peach foliage to

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[25] Smith, Erwin F. Notes on the Michigan Disease known as "Little Peach". *The Fennville* (Mich.) *Herald*, Oct. 15, 1898.

become yellow; but the unthrifty condition brought about by such causes should be carefully distinguished from the genuine yellows. The most reliable symptoms of yellows are premature ripening of the fruit and the occurrence of red streaks in the flesh of the fruit.

BROWN SPOT (*Helminthosporium carpophilum* Lév.).—During the past two years we have frequently seen peach fruits affected with a fungous disease called brown spot. It begins its attack while the fruit is still green, but is most conspicuous on the ripe fruit wheie it apears in the form of pink spots and cinnamon-brown areas. At first the spots are no larger than a pinhead and have a brilliant pink color such as the San José scale insect produces on apples and pears. In the center of the pink spot theie is usually a circular, brown or fawn-colored portion. At this stage the spots are often slightly elevated. In time, the spots coalesce to form irregular areas of cinnamon-brown color and then the pink discoloration of the fruit mostly disappears. Such areas may occupy from one-fifth to one-half of the surface of the fruit and, according to our observations, occur exclusively upon the upper surface. (See Plate XXV, Fig. 2.)

Ordinarily no spores are found in the younger spots, but on the older, brown areas the spores of an *Helminthosporium* occur sparingly. The spores are light brown and mostly 2- to 3-septate although 4- to 6-septate spores are not uncommon. In almost any microscopic preparation containing scrapings from the brown areas there may be found a few of the *Helminthosporium* spores, but they are never abundant. There is little doubt that these spores belong to the fungus which causes the brown areas, and that the fungus is *Helminthosporium carpophilum*[26] Lév.

What seems to be the same fungus[27] has been found on peach branches. Conspicuous enlargements resembling the black knot of plum frequently occur on peach branches in this State. (See

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[26] According to Aderhold (*Centralblatt f. Bakt., Parasitenk. u. Infektionskr.*, II, 5: 523.) *Helminthosporium carpophilum* Lév. is a synonym of *Clasterosporium amygdalearum* Sacc.

[27] The fungus grows readily on the ordinary culture media. The spores germinate freely in tap water and in distilled water; but in the latter med-

Plate XXV, Fig. 1.) Specimens of this peach knot were submitted to Mr. A. D. Selby, botanist of the Ohio Experiment Staton, who identified them as being the same as the "twig disease with gum flow" discussed by him in Ohio Experiment Station Bulletin 92, pages 199-206. The knots are almost invariably covered with gum. In midwinter we examined many of these knots collected in different localities and nearly always found spores of *Helminthosporium* (apparently *H. carpophilum*) in the gum. Sometimes the spores were abundant.

Hyphæ are not abundant in the tissues of the knots. In fact, it is not clear that they contain any hyphæ except occasionally those of saprophytes.

A pure culture of the *Helminthosporium* on the knots was obtained and peach twigs inoculated with it. The inoculated twigs became much blackened at the point of inoculation and there was a copious exudation of gum, while on the check twigs there was no blackening and very little gum. Although the fungus seemed to be parasitic the twigs manifested no tendency to form knots.

In the latter part of the season we occasionally found peach twigs which were killed by the same *Helminthosporium*. In such cases the twig was strangled at a point from 6 to 12 inches back of the tip. At the point of attack the bark was of a gray color and *Helminthosporium* spores were plentiful, but there was no enlargement of the twig.

We have also sought for *Helminthosporium* on peach leaves, but without success except in one instance. In the Station orchard some peach trees, the fruit of which was infested by *Helminthosporium*, showed considerable shot-hole injury on the leaves. An examination of the affected leaves was made September 4. Most of the spots had fallen out, but on those remaining we occasionally found *Helminthosporium* spores iden-

ium the germination is often of a peculiar sort. (See Plate XX, Fig. 7.) The average dimensions of 17 spores grown on sugar beet agar was 13½x35 μ. As found in nature on the fruit and branches they are somewhat smaller.

tical in size and appearance with those found on the fruit, twigs and knots. Sometimes the spores were quite abundant, but again entirely absent.

In short, it may be said that brown spot of peaches is caused by *Helminthosporium carpophilum* which is also sometimes parasitic on the twigs; that it often occurs on the knots and sometimes on the leaves, but whether it is the cause of the knots or is parasitic on the leaves we do not know. It also attacks apricot fruits.

Very little has been written about the disease in America. Taft[28] mentions its occurrence in Michigan, and according to Selby[29] it is common in Ohio. In New York it is, as yet, comparatively unimportant. Selby's experiments indicate that it may be readily controlled by spraying with weak Bordeaux mixture after the fruit has set. However, there is considerable risk in spraying peaches in foliage and it should be avoided if possible.

A DISEASE OF PEACHES IN THE NURSERY CELLAR.—In the winter of 1899-1900 a nurseryman had an interesting experience with peach trees in his nursery cellar. The cellar contained about 10,000 peach trees of several different varieties which were trenched in according to the usual custom. At the time the trees were put in the cellar in the fall some of them were wet and others dry. In trenching them in, sand was thrown over them and allowed to fall down among the branches. On the wet trees considerable sand stuck to the branches.

About January 1 it was noticed that there was something wrong with the trees having sand on their branches. It was found that in many places on the branches there were sections from one to four inches in length on which the bark was dead and black or brown. About 15 per ct. of all the trees in the cellar were more or less affected in this manner, but the trouble was confined entirely to the trees with sand on the branches.

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[28] Taft, L. R., Mich. Agr. Exp. Sta. Bul. 103 : 57–58.

[29] Selby, A. D., Ohio Agr. Exp. Sta. Bul. 92 : 224-225. Selby calls it "brown or pustular spot."

The cause appeared to be a fungus, but its identity is still unknown because we were unable to cultivate it artificially with success. It made but a feeble growth and produced no spores. In the spring we planted some of the diseased trees hoping that the fungus might fruit on the dead branches; but in this, also, we were disappointed.

The owner made an attempt to save the affected trees by removing them from the cellar, washing them and pruning away the diseased branches and then returning them again to the cellar; but without avail. New points of infection appeared and by spring most of the trees were worthless.

Evidently, there is danger in throwing sand on wet trees in the nursery cellar. It is worthy of note that the sand had been used in the cellar continuously for several years.

DOUBLE PEACHES.—Although it is not a pathological condition, we wish to mention that double fruits of peach were unusually abundant last season. On June 6 we observed double peaches very plentiful in a large orchard at Lodi. They occurred on many trees of different varieties in various parts of the orchard. Often, fully 25 per ct. of the fruits were double, and occasionally triple fruits were found. The foreman told us that he had seen quadruple fruits, but we could find none. As a rule the two parts were of about the same size, but sometimes they were very unequal. The majorty of them fell from the trees while small.

On a branch of an Early Crawford tree at Rushville we counted 61 peaches, of which 37 were double and 2 were triple. Another small branch on the same tree bore 12 fruits of which 9 were double and 2 triple.

HAIL INJURY.—Some observations were made on peach trees which had experienced a severe hailstorm two years previous. Upon shaving off the outer layer of bark the inner bark was found to contain numerous brown, corky spots, which were not externally visible. No gum exuded from such injuries or from the wounds made by larger hailstones which broke the bark. Neither did any of the hailstone wounds show any tendency to develop into knots or cankers.

CYTOSPORA.– Dead peach branches are commonly infested by a species of *Cytospora* which is generally believed to be a saprophyte and considered of little importance; but we have so often seen this fungus intimately associated with dead and dying peach trees when no other sufficient cause for disease was evident, that we are becoming suspicious that it is, at least, a semiparasite. Young peach trees found dead in the spring and supposed to have been winter killed, often have the lower part of their trunks thickly covered with pimples. When the outer bark is removed it is seen that the pimples are caused by the presence of flattened, roundish bodies, which in color, size, and shape, resemble flattened shot. The interior of these bodies is white. They are very suggestive of sclerotia. In reality, they are the stromata of *Cytospora*. Eventually, they may become divided into several chambers each containing multitudes of small, curved, hyaline spores. However, under some conditions they may remain indefinitely in the sclerotium-like stage and are then very puzzling to the uninitiated. What appears to be the same fungus occurs on the trunks and branches of apricots and plums. (See pages 181, 201.)

SPLITTING OF THE TRUNK.—In a peach orchard at Trumansburg, 20–25 per ct. of the trees show conspicuous scars on the trunks, chiefly on the southwest side. The owner states that four or five years ago the trunks split from the ground to the crotch as a result of severe freezing. In the spring following the winter in which the injury occurred, the edges of the wounds were trimmed back to the living tissue and painted with Bordeaux mixture. The majority of the trunks have healed over nicely without any injury from rot. One fresh crack was observed which was evidently due to the winter of 1899–1900. The trees are of the variety Elberta and were very vigorous previous to the occurrence of the injury.[30]

OTHER DISEASES.—Black spot or scab, *Cladosporium carpophilum* Thüm, occurred sparingly.

[30] For an illustration of a split peach trunk and a discussion of the treatment of such injury, see Bailey, L. H. The Pruning Book, pp. 122–123. The MacMillan Co., New York, 1898.

We have seen no severe case of gumming except that caused by the fruit bark-beetle, *Scolytus*. In September, the gumming of peach trunks due to the attacks of *Scolytus* was very general in Niagara County. For an account of this see Bulletin 180 of this Station.

Crown gall occurs frequently on nursery stock and occasionally on orchard trees.

We have seen no powdery mildew, *Sphærotheca pannosa* (Wallr.) Lév., the past season.

PEAR DISEASES.

Fire Blight (*Bacillus amylovorus* (Burr.) De Toni.).—This disease was common and did considerable damage, but not as much as usual.

Leaf Scorch.—On August 12 we observed at Geneva a blackening of pear leaves which resembled the work of fire blight, but was, in reality, due to leaf scorch. The trees on which it occurred were of the variety Kieffer, about ten years old, otherwise healthy and growing rapidly. Over a considerable portion of the tops of many trees the leaves were black and dead. For the most part, the injury was confined to about two or three feet of the terminal portion of vigorous shoots of the present season's growth. Only the leaves were affected. The wood was uninjured and this fact is proof that the trouble was not fire blight. In the course of about two weeks most of the blackened leaves fell and the injury was then less conspicuous.

We are convinced that it was weather injury similar to the leaf scorch which appeared on cherries in 1899; but we are at a loss to account for its occurrence this season when cherries have been free from the trouble; whereas, in 1899, cherries suffered from leaf scorch when pears were exempt from it. We know positively that the Kieffer orchard affected with leaf scorch in 1900 was wholly free from it in 1899. Even pear trees mingled with the badly scorched cherry trees in the Maxwell orchard in 1899 showed no signs of leaf scorch.[31]

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[31] See Bul. 162 of this Station, p. 173.

August 6–11, 1900, the week preceding the occurrence of the injury, was the hottest week of the season. It was also very dry and most of the time windy.

Later, the leaf scorch of pears was observed on a few trees in each of several other orchards, and we are informed that it occurred, also, on nursery trees of Kieffer at Dansville.

BODY BLIGHT.—The so-called body blight of pear trunks which is described on page 301 of Bulletin 167 of this Station is very common throughout Western New York. By means of inoculation experiments Paddock[32] has shown that this disease may be produced by the apple canker and black rot fungus, *Sphæropsis malorum* Pk. The same writer observed that the fungus *Macrophoma malorum* (Berk.) Berl. & Vogl. is also of common occurrence on the dead bark on pear trunks, and stated his suspicion that it may play a part in the production of body blight.[33] However, his inoculation experiments with *Macrophoma malorum*, a year later, gave only negative results.[34]

According to our own observations both *Sphæropsis malorum* and *Macrophoma malorum* occur abundantly on the trunks and branches of pear trees affected with body blight. The *Macrophoma* certainly has the appearance of being parasitic and Paddock's inoculation experiments should be repeated before it is finally decided that the fungus is not a parasite.

In order to determine if *Macrophoma malorum* is an immature stage of *Sphæropsis malorum* a pear branch thickly covered with fruiting pycnidia of *Macrophoma* was kept under observation from early May until September. The spores remained hyaline to the end of the period, indicating that the *Macrophoma* is not a stage of *Sphæropsis*, but a distinct species. This conclusion is in harmony with Paddock's observations on *Macrophoma malorum*[35] in cultures.

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[32] Paddock, Wendell. The New York Apple-tree Canker. Bul. 163 of this Station, pp. 184, 203.

[33] L. c.

[34] Bul. 185 of this Station, p. 212.

[35] L. c.

In May the *Macrophoma* expelled its spores on pear in the same manner as on apple. (See page 174.)

In a paper before the Western New York Horticultural Society at its last annual meeting in Rochester, January 23-24, 1901, Mr. Albert Wood[36] stated that he has successfully treated the body blight of pear by washing the trunks with a mixture of whale oil soap, copper sulphate, lime and ashes.

We have searched for *Sphaeropsis* on pear leaves, but found none in Western New York, although some specimens were taken on Long Island. It has not been observed on the fruit.

WINTER AND DROUGHT INJURY.—In May, 1900, a fruit grower at Rushville wrote us concerning the death of some of his pear trees. His orchard consisted of 300 dwarf Duchess pears which had been planted five years and, previous to last year, were thrifty. In the season of 1899, 25 of the trees died, and during 1900 about 20 more of them died. The roots were dead, as was also the bark on the trunk as far up as the union. The soil on which the trees stood was a clay loam with a clay subsoil. Most of the dead trees were on three small knolls where the soil was considerably thinner than in the rest of the orchard.

There was no evidence of fungi or insects. It was evidently a weather injury and probably came about in the following manner: The warm, wet autumn of 1898 induced a late growth which made the trees susceptible to winter injury in the severe winter of 1898-9; and some of the injured trees which survived the drought of 1899 succumbed to the more severe drought of 1900. The character of the soil was, also, favorable to injury from both freezing and drought.

On one of the knolls beside the dead dwarf pears there were some standard pears which were not killed. However, in the Hudson Valley we have observed standard pears on heavy clay soil dying in the same manner and apparently from the same cause.

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[36] Wood, Albert. Experiments with Body Blight on Pear Trees Twelve Years Old. Proceedings Forty-sixth Ann. Meeting W. N. Y. Hort. Soc., p. 24.

MISCELLANEOUS DISEASES.—Scab (*Fusicladium pirinum* (Lib.) Fckl.) was not troublesome. Leaf blight (*Entomosporium maculatum* Lév.) and leaf spot (*Septoria piricola* Desm.) both occurred sparingly throughout the entire district, but neither was destructive. No specimen of genuine rust (*Gymnosporangium*) was taken and russeting of the fruit was not common. Crown gall occurs occasionally on pears in the nursery. Brown, corky spots within the bark may be caused by hailstones as on other fruit trees. The spots are not visible externally.

PLUM DISEASES.

FRUIT ROT (*Monilia fructigena* P.).—Although considerably less destructive than usual, fruit rot was quite prevalent and in some cases caused heavy losses.

Many of the rotten plums remain on the trees over winter. They are called mummy plums or mummies. It is important that such plums be removed from the orchard, because they harbor the rot fungus and in the spring become centers of infection.

We have observed that mummy plums, their pedicels and the twigs bearing them are often covered with a black fungus. On the twig the fungus extends its growth to a distance of two to six inches below the mummy plum, but scarcely at all above it. Evidently, the fungus lives on the juice which the rain washes out of the mummies. Probably, it does the twig little or no harm. It grows partly on the surface and partly beneath the cuticle, causing an eruption which makes the affected twigs quite rough to the touch. Prof. C. H. Peck, to whom the fungus was referred for identification states that it is an undescribed species for which he proposes the name *Coniothecium sociale*.

SUNSCALD.—Some varieties of plums, particularly Reine Claude, are much injured by sunscald. On the southwest side of the trunk a strip of dead bark extends from the ground to the crotch, or even well up on the larger branches. In the advanced stage the dead bark falls away leaving the wood bare. With Reine Claude, sunscald is so common that this variety is

now grown chiefly by topgrafting on varieties not subject to sunscald.

CYTOSPORA.—Plum trunks and branches affected by sunscald are almost invariably infested by a species of *Cytospora*. In the case of a recent injury where the bark is not yet loosened the *Cytospora* is usually found in the sclerotium-like stage described on page 194. The *Cytospora* pimples are very abundant and often occur within half an inch of the living bark. This condition is best observed on the larger branches where the affected areas are depressed and the boundary between the living and dead bark plainly marked. Such areas on the branches usually have open connection with the sunscald injury on the trunk although occasionally an isolated one is found; but in nearly all cases they are covered with *Cytospora*. On injuries of longer standing the *Cytospora* pimples have white tops and are more likely to be found fruiting. In the older injuries there are also occasionally found perithecia of *Valsa*, the mature form of *Cytospora*.

The branches of Japan plums sometimes show isolated areas a few inches long on which the bark is dead and shrunken to the wood. If the branch is a small one it is likely to be slightly enlarged at the point of injury. Such injuries are often called cankers. They generally bear *Cytospora* pimples.

From a canker on Japan plum we obtained a pure culture of the *Cytospora* and inoculated it into six branches of Japan plum —three one-year-old branches and three of the present season's growth. They were inoculated by first abrading the bark, inserting a bit of fungus in the wound and finally covering the point of inoculation with grafting wax. The inoculations were made July 6 and at the same time two checks were prepared on one-year-old branches. In a few days gum began to exude from the inoculations and by the close of the season there were good cankers at all six points of inoculation, while on the checks there was nothing abnormal, not even an exudation of gum.

On July 21 the same *Cytospora* was inoculated into five peach shoots (variety Foster) of the present season's growth in the same manner that the plum branches were inoculated. There

were five checks on the same tree. On November 1 the five inoculated shoots were all gumming freely at the points of inoculation and the wood was disclored, while on the checks there was no exudation of gum and no discoloration of the wood.

It has already been mentioned that the trunks and branches of apricots and peaches are often infested by a species of *Cytospora* which we suspect is parasitic upon them.[*] To all appearances, the *Cytospora* found on apricots and peaches is the same as that found on plums; but the apple *Cytospora* mentioned on page 175 is different. The above experiments indicate that the *Cytospora* of stone fruits may not be the harmless saprophyte which it has heretofore been considered. On the plum it probably aggravates the injury caused by sunscald.

HAIL INJURY.—In April, 1900, while making some observations in a plum orchard near Geneva we found that the plum branches, both large and small, were quite thickly covered with circular spots which were about one-eighth inch in diameter, reddish brown and generally a trifle elevated above the surrounding bark. They were not conspicuous and yet easily detected by one looking for them. On the surface, the bark was smooth and sound, but when cut into it was found to be brown and corky to a depth of 1–2 millimeters.

At first we were puzzled to account for the spots, but upon further examination it was found that they occurred only upon the northwest side of the limbs and were intermingled with hailstone wounds made in the summer of 1898. Underneath the hailstone wounds there was the same brown, corky tissue. Then it became clear that the spots had been caused by hailstones which bruised the bark without breaking it.

Similar spots were found also on the bark of apple, cherry, peach, pear and quince; but, with the exception of cherry, the spots were not externally visible. They were revealed only when the bark was cut into. On the cherry and plum the majority of the spots were visible externally, but on both there were some other spots which could not be located until after the outer layer of bark was removed.

GUM POCKETS IN THE FRUIT.—The plum like the other stone fruits is often subject to gumming, due to various causes. We have observed only one case which is worthy of mention.

During the past four years the fruit on five prune trees in the vicinity of Rochester has been seriously affected with gumming as follows: The trouble begins about the middle of July. It first appears as an irregular spot of a darker green than the normal color of the fruit skin. The spots vary in size, but are usually from one-fourth to one-half inch across, with somewhat indefinite outline. In the early stages the skin of the fruit is unbroken. The tissue underneath is brown and there is a rift or cavity filled with liquid gum. At this time, the discolored tissue has no communication with the pit or with the outer world. Frequently, gum continues to collect in the cavity until the skin bulges prominently. The bulged portion is circular in outline. Finally, a crescent-shaped crack, like a curculio wound, appears at the boundary of the bulge and the gum exudes. The exuded gum hardens and stands out in large drops as on curculio-infested fruits. A conspicuous bulge indicates a large gum pocket. After the exudation of the gum the bulge subsides. In some cases there is no bulging of the skin and no exudation of gum. In advanced stages the skin often takes on a purple color, and one-half or more of the fruit may be involved in disease. Then the injury extends to the pit; in fact, the gum pocket may be in actual contact with the pit. Within the fruit the diseased portion is very irregular in outline and not sharply separated from the healthy tissue. Spots may occur on any part of the fruit but are least common about the stem end. The affected fruits show a tendency to fall prematurely and those which do ripen have hard spots in the flesh. The disease never takes the form of soft rot.

The five trees were heavily loaded and almost every fruit was affected at the time of our visit, July 20. There were no gum pockets on the trunk or branches and no gum exudation of any importance anywhere except on the fruit. The trees were 12 years old and standing in a garden where the soil was a rich, deep

clay loam. Since the variety was a choice one which the owner desired to propagate extensively, the trees were cut back severely in the spring of 1897 to induce a vigorous growth. In August of the same year all wood available for buds was cut off; and in each subsequent year the trees have been cut back in August to get buds for propagation. With the exception of the gumming of the fruit, the trees appeared healthy although they made very little growth during the past two years.

What caused this gumming is not clear. It was certainly not the work of any insect or fungus and probably not of bacteria. At our request Mr. H. A. Harding, the Station Bacteriologist, made Petri-dish cultures of the diseased plum tissue on glucose, lactose and peptone gelatin and lactose agar. In several of the cultures no growth whatever appeared. In others, a few colonies of fungi and bacteria developed, but they were of diverse kinds and evidently foreign to the disease.

We suspect that it was partly the effect of the severe summer pruning. Beach[37] has reported a case in which summer pruning of a cherry tree caused a severe gumming of the trunk; and in a German periodical on plant diseases[38] there is given an account of some experiments which indicate that summer pruning of the stone fruits is favorable to the production of gum. However, in the present case there is certainly another factor to be accounted for: because an unpruned tree of the same variety in the same garden showed traces of the disease as did, also, some other varieties there; and the same disease occurred in a mild form at Geneva on German prunes which had not been pruned to any extent for at least two years.

MISCELLANEOUS DISEASES.—Neither orchard trees nor nursery stock were much injured by leaf blight (*Cylindrosporium padi*). Black knot (*Plowrightia morbosa*) is a serious enemy of plums in Western New York, but it did not spread much last season. Double fruits of plum were common. We found a few specimens of crown gall on nursery stock. No specimens of plum pocket

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[37] Beach, S. A. Gumming of Stone Fruits. *Am. Gardening*, 19 : 606.

[38] *Zeitschrift für Pflanzenkrankheiten*, 6 : 58–59.

or leaf curl (*Exoascus*) or of scab (*Cladosporium carpophilum*) were taken. There is a disease of Japan plums which resembles peach yellows, but we have had little opportunity to study it.

QUINCE DISEASES.

Leaf Blight and Fruit Spot (*Entomosporium maculatum* Lév).—Correspondents report considerable damage done by this disease; still we believe that it has been much less destructive than usual. While the fungus attacks the fruit as well as the leaves it is on the latter that it does the most damage.

We have frequently observed that on quince leaves the *Entomosporium* spots are of two sorts: (1) The typical sort, which is brown, 3 millimeters or more in diameter and bears at the center a black pimple, the acervulus, commonly visible only on the upper surface of the leaf. Two or more such spots may coalesce to form a still larger spot with two to several acervuli. (2) Small black spots, each bearing a single black acervulus which occupies nearly the whole of the spot and is usually visible on both sides of the leaf. Curiously enough the acervuli on the small spots are somewhat larger than those on the large spots, but otherwise they do not differ.

Canker and Black Rot (*Sphæropsis malorum* Pk.)—Some of the quince orchards are seriously affected with canker of the trunk and larger branches. In April we found *Sphæropsis malorum* Pk. fruiting abundantly on cankered limbs. There seems to have been very little black rot of the fruit.

Powdery Mildew (*Podosphæra oxyacanthæ* (DC.) D By).—In August we observed powdery mildew on quinces at Geneva and Penn Yan. At the latter place it was abundant on nearly every tree in a large orchard of young thrifty trees, but apparently it was doing them no damage. We also observed traces of this fungus on quinces at Geneva in 1899.

It occurred only on the upper surface of the leaves and showed a decided preference for the older leaves, rarely attacking the young leaves of the new growth. In both these respects it is in direct contrast with the powdery mildew on cherry, which is

believed to be the same species. As a rule, it is inconspicuous, even when abundant and after the perithecia are formed.

OTHER DISEASES. Fire blight (*Bacillus amylovorus*) did considerable damage, but less than usual. No specimen of rust (*Gymnosporangium*) was taken. Hailstone bruises cause brown, corky spots in the bark like those found on other fruit trees.

RASPBERRY DISEASES.

ANTHRACNOSE (*Glœosporium venetum* Speg.).—It appears that raspberry anthracnose gave very little trouble in 1900. Neither the fruiting canes nor the new growth suffered much from its attacks.

Anthracnose is much more destructive to the black varieties than to the red ones; in fact, it is quite unusual for it to do any serious damage to red raspberries.

During the past season we met with an interesting case in which anthracnose was decidedly injurious to red raspberries of the variety Cuthbert. However, the injury was of a very unusual character. Knots of various sizes up to about two inches in length made their appearance on the canes. The knots were rough, of spongy texture and often had a diameter twice as great as that of the normal cane. (See Plate XXVI.) Our attention was first called to them in November, 1899, and they puzzled us exceedingly. The following spring we visited the affected plantation and made a careful study of the knots without, however, discovering their cause. The plantation was about one-half acre in extent, and we estimated that 10 per ct. of the canes were more or less affected.

It was evident that the knots were not caused by any insect, and there seemed to be no fungus present except the anthracnose fungus, which was not, then, suspected of being the cause of the knots. Although the anthracnose fungus is well known it has never been held responsible for knots on the canes. Similar cane knots are sometimes associated with spongy galls on the roots (crown gall disease), but in this case it was found that root knots

were rare while the cane knots were plentiful, and it was plain that no relation existed between the two kinds of knots.

On August 16 we again visited the plantation for the purpose of studying the disease on the new canes. The knots were already abundant on the new canes and in all stages of development. It was at once observed that the knots were intimately associated with anthracnose. Some of the canes were considerably spotted with anthracnose and such canes were badly knotted. Where anthracnose was most abundant, the knots were most abundant; and where there was no anthracnose, there were no knots. One apparent exception to this rule was found. A cane bearing a single incipient knot appeared to be entirely free from anthracnose. This cane was placed over night in a moist chamber, and the following morning a typical anthracnose spot was seated on the very summit of the forming knot. Upon microscopic examination the spot was found to be fruiting profusely and was undoubtedly anthracnose. The knots were most abundant near the base of the cane and the anthracnose, also, was most abundant on that part of the cane. Occasionally canes were found bearing many anthracnose spots, but no knots. All the anthracnose spots did not produce knots by any means.

Each knot seemed to start in an anthracnose spot. At first a longitudinal crack appears across the anthracnose spot: this crack elongates, becomes brown, and as the knot increases in size the outer bark is gradually thrown off, exposing masses of rough spongy tissue, which takes forms very suggestive of popcorn.

We have seen the same kind of knots, also, on the variety Thompson on the Station grounds; and there existed the same intimate relation between the knots and anthracnose as in the case of the Cuthberts. It is plain that this cane knot of raspberries is caused by the anthracnose fungus. Possibly Bailey's blackberry cane knot[39] may have the same origin.

Rust (*Puccinia peckiana* Howe. Syn. *Cæoma nitens* Schw.).—Rust is a common and destructive disease of black raspberries

[39] Cornell Univ. Agr. Exp. Sta. Bul. 99 : 427–428.

in Western New York, and in 1900 it probably did about the usual amount of damage. Plantations with 10 per ct. of rusty plants were frequent; and occasionally plantations were found in which 25 per ct. or more of the plants were rusty. We have often noticed in Western New York, as in the Hudson Valley, that rusty plants bear fewer prickles. In Chautauqua County the parasitic fungus *Tuberculina persicina*, was common on raspberry rust as well as on blackberry rust. Where the parasite was present the affected plants were less conspicuous, the leaves being purplish instead of bright yellow.

In September the teleuto form was frequently observed.

POWDERY MILDEW (*Oidium ruborum* Rabenh.).—In several localities we observed, during May and June, a powdery mildew on the foliage of black raspberries. In every case it was confined to plants infested by rust, *Cæoma nitens*, never occurring on healthy plants. It occupies both sides of the leaves. No perithecia were found. It is probably referable to *Oidium ruborum* Rabenh. The same mildew has been found on blackberries. (See page 185.)

CANE BLIGHT (*Coniothyrium* sp.).—This is the cane blight described in Bulletin 167, pages 305-307. It has been found to be common in the raspberry plantations of Western New York as well as in the Hudson Valley. At Peruville it injured a crop of Cuthberts to the extent of about 50 per ct. On black varieties it often begins its attack in the dead stub which results from heading back the plants by cutting after they have become large and woody. From this point the disease works its way downward killing successively the lateral branches.

It has now been proven by inoculation experiments with pure cultures that the Sphæropsideous fungus found in such abundance on the diseased canes is really the cause of the disease. (See Plate XXVII.) The fungus properly belongs to the genus *Coniothyrium* rather than to *Phoma* as stated in Bulletin 167. As a rule, the spores are decidedly brownish.

We have also learned to recognize the disease on the young canes. In August and September new canes of red raspberry

PLATE XXVI.—RASPBERRY CANE-KNOT CAUSED BY ANTHRACNOSE: 1, ON OLD CANES; 2, ON NEW CANES.

PLATE XXVII.—RASPBERRY CANE-BLIGHT: 1 AND 3, NATURAL INFECTIONS; 2. FROM ARTIFICIAL INOCULATION.

affected by the disease show brown, black or bluish discoloration of the bark in areas from one to four inches long and extending half to two-thirds or more of the way around the cane.

This raspberry cane blight appears to be an important disease which has been misunderstood by fruit growers and neglected by pathologists. It will be made the subject of a special investigation during the coming season.

OTHER DISEASES.—Leaf spot (*Septoria rubi*) was common but did little if any damage. Crown gall is common and often destructive. In this State crown gall is probably more destructive to the raspberry than to any other plant. It is particularly destructive to the red varieties; for example, Cuthbert and Loudon.

Occasionally one meets with raspberry plants on which the foliage is yellow, dwarfed and curled. The cause is unknown to us.

STRAWBERRY DISEASES.

The only strawberry disease observed in 1900 was leaf blight (*Sphærella fragariæ*) a little of which could be found in almost any strawberry bed, but it does not appear to have been destructive anywhere.

REPORT

ON

Crop Production.

W. H. Jordan, *Director.*
C. G. Jenter, *Assistant Chemist.*

Table of Contents.

COMMERCIAL FERTILIZERS FOR POTATOES. III.*

W. H. JORDAN.

SUMMARY.

(1) Experiments in potato growing conducted for four years on four Long Island farms with fertilizers varying in quantity from 500 lbs. to 2,000 lbs. per acre show that on the average the largest profit was realized from the use of 1,000 lbs.

(2) The so-called Long Island formula, 4, 8 and 10, proved to be superior to a potato formula, 7, 4 and 10.

(3) Experiments with varying quantities of potash gave results which do not justify the use of such large quantities of this ingredient as are now being applied in potato growing by many Long Island farmers whose conditions are similar to those under which these tests were made.

(4) It is clearly evident that a large supply of available plant food does not necessarily insure a satisfactory crop. Other conditions which largely pertain to culture, such as texture, humus and water supply, exercise a controlling influence, and when these conditions are unfavorable their effect is not overcome by heavy applications of fertilizer.

INTRODUCTION.

Experiments in the use of commercial fertilizers in growing potatoes were begun on Long Island in 1895. The results previously reached have been reported in four bulletins, Nos. 93,

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*Reprint of Bulletin No. 187.

132, 137 and 154. The data secured in 1899 and 1900 are given herewith, together with a summary of the outcome of the six years' observations.

The primary object of these experiments was to gain information concerning the quantity of fertilizer which is profitable in potato production under the conditions with which Long Island farmers have to deal.

Other problems incidental to the main one, but perhaps equally important or more so, such as (1) the most efficient mixture of ingredients, (2) the necessity for a generous use of potash in potato growing, (3) the effects of the different forms of potash, (4) the possibility of continuous cropping when only commercial fertilizers are applied to the land and (5) the essential factors in fertility, may be studied in the light of the observed data.

PLAN OF EXPERIMENTS.

The experiment of 1895 and 1896 was conducted on the farm of H. L. Hallock, Jamesport. Twenty-six plats, about one-eighth of an acre each, were used. Ten different brands of fertilizers were applied, each supposed to be especially adapted to potato growing, in quantities of 1,000 lbs., 1,500 lbs. and 2,000 lbs. per acre. The several brands contained from 2.6 to 4.5 per ct. of nitrogen, from 6 to 9.8 per ct. of available phosphoric acid and from 6.2 to 11.5 per ct. of potash.

In 1897 experiments were instituted on four quite widely separated farms on Long Island as follows:

W. A. Fleet, Cutchogue.
H. L. Hallock, Jamesport.
W. L. Jagger, Southampton.
R. H. Robbins, East Williston.

For the first year two acres of land were utilized on each farm and in 1898 another acre was added in each locality. The total number of plats in 1897 was 80 and in 1898, 1899, and 1900 it was 120, the plats being one-tenth acre in size. There were therefore 30 plats on each farm, and the treatment begun the first year was continued uniformly throughout the four years.

FERTILIZERS USED.

The purposes of these experiments as finally arranged required the use of eight different mixtures of fertilizing materials, the ingredients and composition of which are given below.

The several formulas were made up by mixing together varying quantities of nitrate of soda, dried blood, acid phosphate and either the muriate or the sulphate of potash.

It was intended that approximately one-fourth of the nitrogen furnished by these mixtures should be nitric, and three-fourths organic, nitrogen. The manufacturers who mixed the fertilizers were also instructed that the phosphoric acid should be as largely soluble as possible. Analyses of the four mixtures showed that these conditions were secured.

POTATO FORMULA.

This formula is supposed to contain plant foods in nearly the proportions used by the entire potato plant excepting that the phosphoric acid is in considerable excess. The proportion of ingredients was approximately the following:

Composition of Potato Formula.

Nitrogen	7.0 per ct.
Available phos. acid.	4.0 "
Potash	10.0 "

Two mixtures were used under this formula: No. 1, in which the potash was supplied as the muriate, and No. 2, in which it was furnished as the sulphate.

L. I. FORMULA.

This formula is the one so commonly followed by clubs of farmers on Long Island who purchase their fertilizers on the coöperative plan. It was made up from the same materials as the potato formula, mixed in different proportions.

Composition of L. I. Formula.

Nitrogen	4.0 per ct.
Available phos. acid.	8.0 "
Potash	10.0 "

As with the potato formula, the L. I. formula was made up in two mixtures, No. 3 containing the potash as the muriate, and No. 4, as the sulphate.

POTASH TEST FORMULAS.

These formulas were compounded from the same materials as the two already described, the potash varying from nothing in No. 1 to 10 per ct. in No. 4.

FORMULA NO. 1.

Composition.

Nitrogen	4.0 per ct.
Available phos. acid	8.0 "
Potash	0.0 "

FORMULA NO. 2.

Composition.

Nitrogen	4.0 per ct.
Available phos. acid	8.0 "
Potash	3.5 "

FORMULA NO. 3.

Composition.

Nitrogen	4.0 per ct.
Available phos. acid	8.0 "
Potash	7.0 "

FORMULA NO. 4.

Composition.

Nitrogen	4.0 per ct.
Available phos. acid	8.0 "
Potash	10.0 "

The arrangement and numbering of the plats, and the amounts and kinds of fertilizer were the same on each farm. Below can be seen the relation between the number of the plat and the amount and kind of fertilizer:

FERTILIZERS APPLIED ON PLATS.

Potato Formula.

Plat No. 1, no fertilizer.
" 2, 500 lbs. Mixture No. 1.
" 3, 1000 " "
" 4, 1500 " "
" 5, 2000 " "
" 6, no fertilizer.
" 7, 500 lbs. Mixture No. 2.
" 8, 1000 " "
" 9, 1500 " "
" 10, 2000 " "

L. I. Formula.

Plat No. 11, no fertilizer.
" 12, 500 lbs. Mixture No. 3.
" 13, 1000 " "
" 14, 1500 " "
" 15, 2000 " "
" 16, no fertilizer.
" 17, 500 lbs. Mixture No. 4.
" 18, 1000 " "
" 19, 1500 " "
" 20, 2000 " "

Potash Test Formulas.

Plats 21 and 26.	No fertilizer.
" 22 and 27.	Formula No. 1.
" 23 and 28.	" " 2.
" 24 and 29.	" " 3.
" 25 and 30.	" " 4.

The total number of plats on the four farms to which each particular quantity of fertilizer was applied is seen to be sixteen, excepting that each potash test mixture was applied to only eight.

GENERAL CONDITIONS ATTENDING EXPERIMENTS.

It is seen by referring to Bulletin 137 that the crop of 1897 was planted on timothy sod in two cases and on corn stubble in two.

Nothing in the way of organic matter was added to any plat for the first two years of the experiments. In 1898 Fleet and Hallock sowed crimson clover after the potato crop was harvested and Jagger sowed rye. In neither case did the clover amount to much. The rye, on the plats receiving 1,000 lbs. of fertilizer per acre or over, had made a thick growth of four inches in height when it was plowed down on April 2, 1899.

In 1899 crimson clover was sown on all four farms after the potatoes were dug.

On Fleet's farm the clover winter-killed considerably, and where it did not the growth was rather small. Hallock reported a heavy growth in the fall which was continued in the spring until plowing. The clover made a slendid sod in Jagger's field excepting where grasshoppers worked, on which part rye was sown with success. Robbins sowed the clover seed rather late, but the plants made a fairly good catch, and when plowed under in the spring covered most of the ground.

Reference to the figures for the yield of potatoes in 1899 shows that the crop was very small and in marked contrast to the crops of the two previous years. This is explained by the severe drought which prevailed all over Long Island during the growing season for early potatoes. The crop for 1900 was larger but not satisfactory.

It should be said that these fields of potatos were under the care of experienced and reliable farmers, and were given the care believed to be essential to successful potato growing.

EXPERIMENTS IN 1899 AND 1900.

In the following tables are given the results in detail of the yields of potatoes during 1899 and 1900. Similar data for 1897 and 1898 may be found in Bulletins 137 and 154.

TABLES SHOWING THE YIELDS IN DETAIL AND PER ACRE.

TABLE I.—YIELD OF POTATOES ON ONE-TENTH ACRE PLATS, 1899.

Fertilizer.	No. of plat.	Amount of fertilizer per acre.	Potatoes on One-tenth Acre Plats on Farms of											
			Wm. A. Fleet.			H. L. Hallock.			W. L. Jagger.			R. H. Robbins.		
			Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Potato Formula Mixture 1	1	0	30	91	121	16	123	139	54	116	170	12	123	135
	2	500	63	156	219	18	107	125	116	171	287	50	182	232
	3	1000	97	165	262	62	171	233	98	106	204	305	102	407
	4	1500	157	159	316	40	173	213	162	108	270	205	160	365
	5	2000	152	197	349	80	216	296	251	163	414	213	120	333
Potato Formula Mixture 2	6	0	40	160	200	9	92	101	114	156	270	106	206	312
	7	500	34	134	168	34	106	140	257	278	535	94	161	255
	8	1000	112	197	309	56	164	220	336	148	484	100	145	245
	9	1500	140	177	317	51	165	216	199	86	285	106	121	227
	10	2000	128	212	340	104	214	318	256	195	451	260	70	330
L. I. Formula. Mixture 3	11	0	10	90	100	3	91	94	27	361	163	151	214	365
	12	500	17	121	138	19	156	175	102	175	277	112	185	297
	13	1000	63	182	245	55	206	261	215	193	408	217	164	381
	14	1500	96	190	286	117	214	331	314	154	468	244	287	531
	15	2000	103	207	310	194	202	396	300	178	478	333	163	496
L. I. Formula. Mixture 4	16	0	40	144	184	15	83	98	2	28	30	202	218	420
	17	500	21	145	166	34	176	210	73	140	213	103	288	391
	18	1000	43	191	234	74	195	269	141	183	324	153	203	356
	19	1500	35	151	186	174	228	402	154	195	349	157	213	370
	20	2000	111	284	395	260	223	483	272	244	516	265	191	456

TABLE II.—AVERAGE YIELD OF POTATOES PER ACRE FROM DIFFERENT AMOUNTS OF FERTILIZER, 1899.

		YIELD OF POTATOES WITH														
		NO FERTILIZER.			500 LBS FERTILIZER.			1000 LBS. FERTILIZER.			1500 LBS FERTILIZER.			2000 LBS. FERTILIZER.		
EXPERIMENTER.	No. of plats averaged	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu*	*Bu.*	*Bu*	*Bu.*	*Bu*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Wm. A. Fleet.....	4	5.0	20.2	25.2	5.6	23.2	28.8	13.1	30.6	43.7	17.8	28.2	46.0	20.6	37.5	58.1
H. L. Hallock....	4	1.8	16.2	18.0	4.4	22.7	27.1	10.3	30.7	41.0	15.9	32.5	48.4	26.6	35.6	62.2
W. L. Jagger.....	4	8.2	18.2	26.4	22.8	31.8	54.6	32.9	26.3	59.2	34.6	22.6	57.2	45.0	32.5	77.5
R. H. Robbins....	4	19.6	31.7	51.3	15.0	34.0	49.0	32.3	25.6	57.9	29.7	32.5	62.2	44.6	22.7	67.3
Average of all....		8.6	21.6	30.2	12.0	27.9	39.9	22.2	28.3	50.5	24.5	29.0	53.5	34.2	32.1	66.2
Av. increase of yield					3.4		9.7	13.6		20.3	15.9		23.3	25.6		36.0

TABLE III.—YIELD OF POTATOES ON ONE-TENTH ACRE PLATS, 1900.

Fertilizer.	No. of plat.	Amount of fertilizer per acre.	W. A. Fleet. Large.	W. A. Fleet. Small.	W. A. Fleet. Total.	H. L. Hallock. Large.	H. L. Hallock. Small.	H. L. Hallock. Total.	W. L. Jagger. Large.	W. L. Jagger. Small.	W. L. Jagger. Total.	R. H. Robbins. Large.	R. H. Robbins. Small.	R. H. Robbins. Total.
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Potato Formula, Mixture 1	1	0	509	70	579	29	62	91	191	140	331	440	220	660
	2	500	597	76	673	64	72	136	279	146	425	412	192	604
	3	1000	827	45	872	68	86	154	452	142	594	440	165	605
	4	1500	855	61	916	86	103	189	462	137	599	450	175	625
	5	2000	931	56	987	100	89	189	546	137	683	385	166	551
Potato Formula, Mixture 2	6	0	618	54	672	49	80	129	235	107	342	445	160	605
	7	500	697	65	762	111	100	211	238	128	366	485	120	605
	8	1000	785	39	824	112	111	223	484	135	619	550	165	715
	9	1500	840	82	922	207	125	332	376	108	484	605	175	780
	10	2000	802	51	853	244	97	341	448	131	579	580	170	750
L. I. Formula, Mixture 3	11	0	582	80	662	17	60	77	118	81	199	450	155	605
	12	500	540	72	612	90	135	225	212	128	340	577	192	769
	13	1000	798	65	863	116	108	224	324	173	497	580	178	758
	14	1500	1062	76	1138	202	94	296	517	166	683	842	187	1029
	15	2000	959	57	1016	211	140	351	517	182	699	660	172	832
L. I. Formula, Mixture 4	16	0	530	78	608	49	81	130	104	100	204	440	192	632
	17	500	675	95	770	133	136	269	268	153	421	880	220	1100
	18	1000	734	67	801	231	180	411	522	186	708	680	185	865
	19	1500	928	66	994	333	133	466	654	189	843	622	230	852
	20	2000	854	66	920	420	164	584	818	233	1051	630	170	800

The farm columns are grouped under the heading "Potatoes on One-tenth Acre Plats on Farms of".

TABLE IV.—AVERAGE YIELD OF POTATOES PER ACRE FROM DIFFERENT AMOUNTS OF FERTILIZER, 1900.

EXPERIMENTER.	Number of plats averaged.	Yield of Potatoes with: No fertilizer.			500 lbs. fertilizer.			1000 lbs. fertilizer.			1500 lbs fertilizer.			2000 lbs. fertilizer.		
		Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu	Bu.	Bu	Bu	Bu	Bu.	Bu.
Wm. A. Fleet.....	4	93.3	11.8	105.1	104.6	12.8	117.4	131.0	9.0	140.0	153.6	11.9	165.5	147.7	9.6	157.3
H. L. Hallock....	4	6.0	11.8	17.1	16.6	18.5	35.1	21.9	20.2	42.1	34.5	19.0	53.5	40.6	20.4	61.0
W. L. Jagger....	4	27.0	17.8	44.8	41.5	23.1	64.6	74.3	26.5	100.8	83.7	25.0	108.7	97.0	28.5	125.5
R. H. Robbins....	4	74.0	30.3	104.3	98.1	30.2	128.3	93.7	28.9	122.6	105.0	32.0	137.0	94.0	28.2	122.2
Average of all....		50.0	17.9	67.9	65.2	21.2	86.4	80.2	21.2	101.4	94.2	22.0	116.2	94.8	21.7	116.5
Av. increase of yield					15.2		18.5	30.2		33.5	44.2		48.3	44.8		48.6

TABLE V.—RESULTS WITH POTASH-TEST FORMULAS, 1899.

YIELD OF POTATOES ON ONE-TENTH ACRE PLATS.

	No. of plat.	Amount fertilizer per acre.	WM. A. FLEET.			H. L. HALLOCK.			W. L. JAGGER.			R. H. ROBBINS.		
			Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs*	*Lbs.*	*Lbs*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
	21	......	45	161	206	68	111	179	245	287	532	250	74	324
Formula 1..	22	1000	94	193	287	145	136	281	605	222	827	305	170	475
Formula 2..	23	1000	85	201	286	164	140	304	691	235	926	308	135	443
Formula 3..	24	1000	94	161	255	190	146	336	779	232	1011	230	150	380
Formula 4..	25	1000	99	211	310	163	113	276	745	250	995	398	70	468
	26	......	30	91	121	56	120	176	339	221	560	240	97	337
Formula 1..	27	1000	165	197	362	146	131	277	527	213	740	220	138	358
Formula 2..	28	1000	224	205	429	138	135	273	513	217	730	248	230	470
Formula 3..	29	1000	180	237	417	162	141	303	601	221	822	425	127	552
Formula 4..	30	1000	205	204	409	114	150	264	567	199	766	450	195	645

TABLE VI.—SUMMARY OF YIELDS PER ACRE OF POTATOES WITH VARYING AMOUNTS OF POTASH, 1899.

EXPERIMENTER.	NOTHING.			NO POTASH.			1-3 POTASH.			2-3 POTASH.			3-3 POTASH.		
	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.	Large.	Small.	Total.
	Bu.	*Bu.*	*Bu*	*Bu.*	*Bu*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu*
Wm. A. Fleet.....	6.3	21.0	27.3	21.6	32.5	54.1	25.8	33.8	59.6	22.8	33.2	56.0	25.3	34.6	59.9
H. L. Hallock....	10.3	19.3	29.6	24.2	22.3	46.5	25.2	22.9	48.1	29.3	23.9	53.2	23.1	21.9	45.0
W. L. Jagger.....	48.7	42.3	91.0	94.3	36.3	130.6	100.3	37.7	138.0	115.0	37.8	152.8	109.3	37.4	146.7
R. H. Robbins....	40.8	14.3	55.1	43.8	25.7	69.5	46.3	30.4	76.7	54.6	23.1	77.7	70.7	22.1	92.8
Average of all....	26.5	24.2	50.7	46.0	29.2	75.2	49.4	31.2	80.6	55.4	29.5	84.9	57.1	29.0	86.1
Av. increase				19.5		24.5	22.9		29.9	28.9		34.2	30.6		35.4

TABLE VII.—RESULTS WITH POTASH-TEST FORMULAS, 1900.

YIELD OF POTATOES ON ONE-TENTH ACRE PLAT.

	No. of plat.	Amount fertilizer per acre.	Wm A. Fleet. Large.	Small.	Total.	H L. Hallock. Large.	Small.	Total.	W. L. Jagger. Large.	Small.	Total.	R. H Robbins. Large.	Small.	Total.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
	21	......	653	117	770	74	76	150	233	121	354	220	124	344
Formula 1..	22	1000	862	119	981	157	121	278	400	163	563	330	152	482
Formula 2..	23	1000	780	100	880	208	136	344	441	189	630	412	178	590
Formula 3..	24	1000	835	93	928	318	111	429	424	156	580	440	138	578
Formula 4..	25	1000	853	80	933	455	111	566	377	145	522	371	112	483
	26	......	484	122	606	22	38	60	342	111	453	330	125	455
Formula 1..	27	1000	850	83	933	66	83	149	375	155	530	317	115	432
Formula 2..	28	1000	874	81	955	85	75	160	427	151	578	442	170	612
Formula 3..	29	1000	870	68	938	100	82	182	486	138	624	385	189	574
Formula 4..	30	1000	675	76	751	181	92	273	396	134	530	382	165	547

TABLE VIII.—SUMMARY OF YIELDS PER ACRE OF POTATOES WITH VARYING AMOUNTS OF POTASH, 1900.

	Nothing. Large.	Small.	Total.	No Potash. Large.	Small.	Total.	1–3 Potash. Large.	Small.	Total.	2–3 Potash. Large.	Small	Total.	3–3 Potash. Large.	Small.	Total.
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu*	*Bu*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Wm. A. Fleet..	94.8	19.9	114.7	142.7	16.8	159.5	137.9	15.1	153.0	142.1	13.4	155.5	127.3	13.0	140.3
H. L. Hallock.	8.0	9.5	17.5	18.6	17.0	35.6	24.4	17.6	42.0	34.8	16.1	50.9	53.0	16.9	69.9
W. L. Jagger..	47.9	19.3	67.2	64.6	26.5	91.1	72.3	28.3	100.6	75.8	24.5	100.3	64.4	23.3	87.7
R. H. Robbins.	45.8	20.8	66.6	53.9	22.3	76.2	71.2	29.0	100.2	68.8	27.2	96.0	62.8	23.0	85.8
Average of all.	49.1	17.4	66.5	70.0	20.6	90.6	76.5	22.5	99.0	80.4	20.3	100.7	76.9	19.0	95.9
Av. increase...				20.9		24.1	27.4		32.5	31.3		34.2	27.8		

DISCUSSION OF RESULTS.

The data from these experiments, which have been very fully given in this and previous bulletins, bear upon three main points which are important to Long Island potato growers, or those producing potatoes under similar conditions: (1) The relation to profit of the quantity of fertilizer applied; (2) the most desirable mixture of fertilizing ingredients, with especial reference to (3) the necessary amount of potash.

THE QUANTITY OF FERTILIZER.

For profit.—The experiments conducted by Dr. Van Slyke in 1895 and 1896 led to the conclusion that "the use of over 1,000 pounds of fertilizer an acre under the conditions tried was attended with loss, as compared with the results obtained in using 1,000 pounds of fertilizer."

The results from 1897 to 1900 inclusive are summarized in the following table:

TABLE IX.—INCREASE OF YIELD OF POTATOES FROM DIFFERENT QUANTITIES OF FERTILIZER, FOUR YEARS.

Amount of fertilizer per acre.	Increase* 1897.		Increase 1898.		Increase 1899.		Increase 1900.		Average Increase.	
	Large.	Total.	Large.	Total.	Large.	Total.	Large.	Total.	Large.	Total.
Lbs.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
500	34.1	31.6	33.2	33.4	3.4	9.7	15.2	18.5	21.5	23.3
1000	69.1	62.3	61.8	60.7	13.6	20.3	30.2	33.5	43.7	44.2
1500	77.5	65.1	85.8	84.8	15.9	23.3	44.2	48.3	55.8	55.4
2000	78.7	71.3	89.9	89.7	25.6	36.0	44.8	48.6	59.7	61.4

*Average of Fleet and Hallock plats.

It is very evident that the increase in yield is not proportional to the quantity of fertilizer applied. As an average for four years, the first 500 lbs. caused an increased yield of 23.3 bushels; the second 500 lbs., 21.9 bushels; the third 500 lbs., 11.2 bushels; and the fourth 500 lbs., 6 bushels. The fertilizer (L. I. Formulas) cost about $25.00 per ton. If we assume that the potatoes were worth 50 cents per bushel we have the balances as shown below.

Amount of fertilizer per acre.	Cost of fertilizer.	Increased yield of potatoes.	Money gain from use of fertilizer.
Lbs.		*Bu.*	
500	$6 25	23.3	$5 40
1000	12 50	44.2	10.60
1500	18 75	55.4	8 95
2000	25 00	61.4	5.70

Considering the four years' crops as a whole the largest money profit came from the use of one thousand pounds of fertilizer.

For crop needs.—This matter may be looked at from another side, viz.: The relation of the nitrogen, phosphoric acid and potash in the fertilizer to the amounts of their ingredients taken up by the tubers and tops.

There are two points of view from which to discuss the use of fertilizers—the needs of the crop, and the capacity of the soil to supply plant food. In this instance the capacity of the soil at its weakest point is measured by the yield of potatoes where no fertilizer was applied.

In making the comparisons which follow, the weight of tops is assumed to be two-thirds that of the tubers and the composition of the tubers and tops is taken from the averages of German analyses which are somewhat higher for tubers than American analyses.

Table X gives a comparison between the largest quantities of nitrogen, phosphoric acid and potash which the average crop was likely to have taken up, and the amounts of these ingredients in the fertilizer applied.

Table X.—Fertilizer Elements in Crops and in Fertilizers.

Amount fertilizer per acre.	Weight of Crop.		Nitrogen.			Phosphoric Acid			Potash.		
	Tubers.	Tops.	In total crop.	In fertilizer. L. I. F.	In fertilizer. P. F.	In total crop.	In fertilizer. L. I. F.	In fertilizer. P. F.	In total crop.	In fertilizer. L. I. F.	In fertilizer. P. F.
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
	4776	3184	36	....	....	11.4	....	....	41.7	...	...
500	6174	4116	46.9	20	35	14.7	40	20	53.9	50	50
1000	7428	4592	56.4	40	70	17.8	80	40	64.9	100	100
1500	8100	5400	61.5	60	105	19.5	120	60	70.8	150	150
2000	8460	5640	64.3	80	140	20.3	160	80	73.8	200	200

Table XI shows the relation between the quantity of plant food needed for the increase of crop and that applied in the fertilizers.

TABLE XI.—FERTILIZER ELEMENTS IN FERTILIZERS AND IN CROP INCREASE PRODUCED.

Amount fertilizer per acre.	Nitrogen.			Phosphoric Acid.			Potash.		
	In increased yield.	Applied in L. I. formula.	Applied in potato formula.	In increased yield.	Applied in L. I. formula.	Applied in potato formula.	In increased yield.	Applied in L. I. formula.	Applied in potato formula.
500	10.9	20	35	3.4	40	20	12.2	50	50
1000	20.4	40	70	6.4	80	40	23.2	100	100
1500	25.5	60	105	8.1	120	60	29.1	150	150
2000	28.3	80	140	8.9	160	80	32.7	200	200

These figures make it very evident that, with the exception of the nitrogen, the fertilizers in quantities of 1,000 lbs. or over furnished the three important ingredients in great excess over what the crops used, and in much greater excess, nitrogen included, over the needs of the crops above what the soil could supply. Such facts as these force us to the conclusion that crop production is largely dependent upon factors other than the mere supply of plant food. If, therefore, Long Island farmers, or any others, for that matter, are to apply commercial fertilizers in such generous amounts, they must give careful attention to other soil conditions, such as water and humus supply if they are to reap adequate returns.

THE KIND OF FERTILIZER.

The favorite fertilizer formula with Long Island farmers for potato growing has for some years been nitrogen 4 per ct., phosphoric acid 8 per ct., and potash 10 per ct. The formula more nearly conforming to the proportions of the three ingredients in the potato crop is nitrogen 7 per ct., phosphoric acid 3 per ct., and potash 10 per ct. Table XII shows the results of an experimental comparison of these two formulas for four years.

The Long Island formula appears to have been uniformly more efficient than the potato formula. As the former contained as much potash as the latter, and more nitrogen, its superiority

must be due to its greater proportion of phosphoric acid, even though both mixtures supplied this ingredient in large excess above the needs of the crop. This leads to the observation that we are still much in the dark concerning the recoverableness of the compounds which we apply to the soil in fertilizers.

THE NECESSARY AMOUNT OF POTASH IN GROWING POTATOES.

In some way farmers have come to believe that the potato plant demands heavy feeding with potash. This view has found expression in the so-called "potato fertilizers" which are offered to potato growers in great variety of name and composition, the characteristic feature of which is their high percentage of potash. Just how rational this common notion is, is a matter of doubt. Potatoes are not alone in utilizing potash freely during growth, and its probable that this crop is not greatly unlike many others, including roots and forage crops, in its fertilizer requirements under given conditions.

Some years ago, many farmers on Long Island came to regard a generous use of potash as advisable in potato culture, and the 4, 8 and 10 formula was adopted. On what experimental data this conclusion rested, the writer is not informed.

In 1898 experiments touching this point were begun on the four farms mentioned and the same method of treatment has been continued on the same plats for three years. The results are summarized in Table XIII.

TABLE XII.—SUMMARY OF YIELDS OF POTATOES WITH "POTATO" FORMULA AND L. I. FORMULA.

Amount of fertilizer per acre.	1897.* Potato formula.	1897.* L. I. formula.	1897.* Excess from L. I. formula.	1898. Potato formula.	1898. L. I. formula.	1898. Excess from L. I. formula.	1899. Potato formula.	1899. L. I. formula.	1899. Excess from L. I. formula.	1900. Potato formula.	1900. L. I. formula.	1900. Excess from L. I. formula.
None		113.1			107.4			30.2			67.9	
500 lbs...	125.5	163.8	38.3	138.0	143.5	5.5	40.9	38.9	—2	78.8	93.9	15.1
1000 lbs...	166.2	184.7	18.5	167.7	168.4	0.7	49.3	51.6	2.3	96.0	106.8	10.8
1500 lbs...	166.8	189.5	22.7	188.2	196.2	8.0	46.0	60.9	14.9	101.0	131.0	30.3
2000 lbs...	178.4	190.4	12.0	191.7	202.6	10.9	59.0	73.5	14.5	112.9	130.3	17.4

*From Fleet and Hallock plats.

TABLE XIII.—RESULTS FROM POTASH-TEST FORMULAS.

Number of plats averaged.	PLANT FOOD APPLIED PER ACRE IN 1000 LBS. FERTILIZER.	1898. Yield. Large. Bu.	1898. Yield. Total. Bu.	1898. Gain. Large. Bu.	1898. Gain. Total. Bu.	1899. Yield. Large. Bu.	1899. Yield. Total. Bu.	1899. Gain. Large. Bu.	1899. Gain. Total. Bu.	1900. Yield. Large. Bu.	1900. Yield. Total. Bu.	1900. Gain. Large. Bu.	1900. Gain. Total. Bu.
8	No fertilizer..................	123.0	149.9			26.5	50.7			49.1	66.5		
8	40 lbs. nitrogen, 80 lbs. phos. acid and no potash.........	177.9	204.0	56.9	54.1	46.0	75.2	19.5	24.5	70.0	90.6	20.9	24.1
8	40 lbs. nitrogen, 80 lbs. phos. acid and 35 lbs. potash.....	179.3	203.7	54.3	53.8	49.4	80.6	22.9	29.9	76.5	99.0	27.4	32.5
8	40 lbs. nitrogen, 80 lbs. phos. acid and 70 lbs. potash......	178.4	202.6	55.4	52.7	55.5	84.9	29.0	34.2	80.4	100.7	31.3	34.2
8	40 lbs. nitrogen, 80 lbs. phos. acid and 100 lbs. potash....	180.8	203.5	57.8	53.6	57.1	86.1	30.6	35.4	76.9	95.9	27.8	29.4

In 1898, the first year, when the yield of potatoes was fairly large, the entire absence of potash from the fertilizer was without influence on any one of the four farms. Forty pounds of nitrogen and eighty pounds of phosphoric acid per acre without potash caused as large an increase of tubers as when accompanied by one hundred pounds of potash. In the two succeeding years, while the crops were small on all plats, potash either in small or large proportions had little effect. It must be conceded that up to the point to which these experiments have been carried, nitrogen and phosphoric acid, one or both, were the ingredients upon which dependence could be placed as a source of profit.

Experimental results no more extensive than those herewith reported should not be taken as justifying the exclusion of potash from commercial fertilizers. This is in any case a local question. There are good reasons for inquiring, however, whether, considering the capacity of our soils and in view of considerable experimental data, the importance of potash salts has not been somewhat overestimated by Long Island potato growers.

PRACTICAL LESSONS TAUGHT BY THESE EXPERIMENTS.

It seems to the writer that practical lessons of great value may be drawn from the results of these experiments. In the first place, it is clearly shown that the use of very large quantities of commercial plant food is attended with great financial risk unless all conditions of soil and season are favorable. But even when the best conditions prevail, the largest crop which may be secured by a very liberal application of fertilizers is not necessarily the most profitable. The money balance from a medium crop may often be larger than from a maximum yield for the reason that the fertilizer cost per unit of production increases very rapidly after the production passes a certain point. It is only with very high priced crops that excessive feeding is justifiable from the standpoint of good business management.

Again, it is well worth much time and careful observation to discover the needs of a soil upon which commercial fertilizers are

to be continuously used. The outcome of extensive experiments for four years on four farms presents good reasons for questioning the wisdom, under the conditions involved, of applying more potash on potatoes than any other ingredient. It is now a trite statement, but a true one, that each farmer must discover for himself the fertilizer needs of his farm. Such experiments as these are suggestive, but the results are put to their best use when they serve as the basis for similar observations by individual farmers.

One fact, no less important than any other mentioned, to which these experiments point, is that the proportion of available plant food in the soil is only one factor in crop production. It is not enough that a plant have within reach all the raw materials from the mineral world that it needs for luxuriant growth. Its environment must be congenial both in the soil and out of it, if the raw materials are to be appropriated to the maximum extent. This means that soil texture and warmth, conditions which are largely dependent upon culture and the supply of humus, must be given careful attention. The result of neglecting these conditions can never be fully overcome by the liberal purchase of fertilizers.

THE SUBSTITUTION OF SODA FOR POTASH IN PLANT GROWTH.*

W. H. Jordan and C. G. Jenter.

SUMMARY.

Experiments relating to the possibility of substituting soda for potash in plant growth have been carried on during two years, with the following results:

(1) A deficiency of available potash greatly depressed the growth of the plant even in the presence of an abundant supply of soda salts. A lack of soda in the presence of potash sufficient for the plant's needs seemed to have no deleterious effect whatever upon growth.

(2) Plants to which the necessary supply of potash was not accessible took up more soda than when potash was present in abundance. Soda may be substituted for potash in quantity when the latter is lacking.

(3) While the substitution may take place in quantity, it evidently cannot do so in function, as is shown by the limited growth when the plants were deprived of potash, even though soda was appropriated in increased proportions.

(4) The experiments incidentally suggest the view that the real need of plants for certain essential mineral constituents is not even approximately measured by the proportions of these constituents which the plant takes up.

*Reprint of Bulletin No. 192.

CHEMICAL ELEMENTS IN PLANTS.

One of the questions which early engaged the attention of chemists and plant physiologists was the determination of the number and function of the elements necessary for the growth of plants. Numerous investigations, few of which have been conducted within recent years, have, without question, justified the conclusion that at least eleven elements are essentially involved in the normal development of agricultural plants. Whether or not certain others, ordinarily found in vegetable tissue, are requisite to the functions of plant life, or at least to its well being, is a question which so far does not appear to have been definitely settled. Moreover, concerning the necessary proportions of the mineral ingredients of plants no satisfactory conclusions seem to have been reached. It does not yet appear, for instance, that, because wheat takes up sodium, this species of grain must have this element in order to attain full development, or that when a certain quantity of potassium is found in a particular wheat crop, less of this element might not have met all requirements. Our present state of knowledge allows us to infer that a plant in appropriating raw materials for constructive purposes may exercise a selective power not strictly in accordance with its exact needs. It may possibly absorb materials unnecessary either in the kind or in the quantity used. Notwithstanding all this, it is clearly established that all the elements of the organic part of a plant are absolutely essential to growth and that in the absence of some of those found in the ash, growth, if it takes place at all, goes on abnormally.

POTASH AND SODA.

Since the earliest investigations of thirty years ago or more it has been taught that agricultural plants cannot attain normal development in the absence of potash. Concerning the essentialness of soda to plant life, more or less doubt still exists. It is generally believed by agricultural chemists that if it is necessary at all, only minute quantities are needed. While these views

represent the consensus of opinion among scientific men at the present time, current popular thought has been thrown more or less into confusion on these points by recent newspaper discussions over the substitution of soda for potash in feeding plants. This discussion was started and largely maintained by the late Andrew H. Ward and, aided by the press, he so persistently exploited his belief in the possibility of this substitution to the advantage of the farmer that he made more or less impression upon the views of the agricultural public. This writer was able to present little or no experimental proof of his position, his arguments being largely assertions. In view of the situation it was thought wise to institute experiments touching this matter, not because of anything new in the scientific evidence advanced which should cause the question to be reopened, but rather to be able to throw into the argument more experimental data of recent origin. It is desirable before presenting the plan of these experiments and the results obtained, to review somewhat briefly the evidence furnished by past investigations, without attempting, however, to compile a monograph on the subject.

RESULTS OF PREVIOUS INVESTIGATIONS.

W. Knop[1] concluded in regard to the growth of maize that in the first period of growth the plant may get along without soda, yet for the full development of the plant, soda must be added to the plant food.

Hellriegel[2] studied the potash need of barley, using "quartz sand almost potash-free," and potash salts in quantities from 0 to 282 parts per million of soil. He found that 47 parts per million was sufficient for the maximum growth. The use of larger amounts of potash did not seem to cause a greater yield, but the potash was taken up by the straw in larger proportions.

Nobbe, Schroeder and Erdman[3] found that in a nutritive solu-

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[1]Abstracted in *Jahrb. f. Agr. Chem.*, 4 : 127.

[2]Abstracted in *Jahrb. f. Agr. Chem.*, 10 : 117.

[3]*Landw. Vers. Stat.*, 13 : 321 and 401, abstracted in *Jahrb. f Agr. Chem.*, 14 : 104.

tion, complete with the exception of potash, the plants grew no better than in pure water. There was no assimilation and no actual growth, because without the action of potash no starch is formed in the chlorophyl bodies.

Potassium chloride was found to be the best form of potash for buckwheat, the nitrate being next in usefulness. If all the potash is given in form of sulphate or phosphate, there will develop sooner or later a disease, due to the "passive accumulation" of starch; which is not transported so that it may be of use to the plant.

Sodium and lithium could not replace potash. While the sodium was simply useless for the plant, the lithium in the cell sap had an injurious action on the plant tissues.

M. Mercadante[4] grew oxalis and rumex without potash. The plants did not bear fruit or flowers. The sap contained about one-eighth the free acid found in a normal plant. Besides the oxalic acid the sap also contained tartaric acid, both being in combination with lime. Only small amounts of sugar and starch were found in the sap.

A. Pagnoul[5] reached the conclusion that ash of potatoes, fertilized with both soda and potash salts, did not contain even a trace of soda. The roots assimilated the potash but none of the soda.

M. Georges Ville[6] studying the action of salts in quartz sand, says in regard to potash: "As soon as this alkali is lacking in the soil, the plant suffers greatly; the stalk, instead of growing vertically, bends as if it wanted solidity. It does not die, however, but the yield scarcely reaches 92 grains." The complete fertilizer gave 337-400 grains.

" From a chemical point of view the closest resemblance exists between potash and soda, * * * but to the plant there is a vast difference, for in the experiment in which the potash was suppressed, and where vegetation suffered so much, the soil was

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[4] *Jahrb. f. Agr. Chem.*, 18 : 257.

[5] *Comptes rendus*, 80 : 1010, abstracted *Jahrb. f. Agr. Chem.*, 18 : 259.

[6] Artificial Manures, p. 154.

largely provided with soda. It is, then, an acknowledged fact that soda cannot take the place of potash."

Oscar Loew[7] states that: "The paramount importance of potassium salts for every living cell is firmly established. * * * These salts can never be replaced by lithium or sodium salts, but in certain fungi they may be replaced to a limited extent by rubidium or cæsium salts. * * * The fact that many kinds of plants have been raised to perfection in the absence of sodium salts proves that the latter have no indispensable functions to perform in plant life. * * * Nevertheless, sodium salts may sometimes exert a beneficial action, and several observers ascribe to them a promoting action in the ripening process of the Gramineæ." * * *

In regard to rubidium chloride he sums up some experiments as follows: "These experiments proved that it is impossible to raise normal seed-bearing buckwheat plants when the potassium chloride in the culture solution is replaced by rubidium chloride, but on the other hand they left hardly any doubt that rubidium chloride can serve for certain physiological functions of which sodium chloride is utterly incapable. With rubidium chloride, buckwheat plants may reach a dry weight of even thirty-seven times that of the seeds, but with sodium chloride they seldom reach over five times. In a normally raised plant, however, the dry matter may be over six hundred times the weight of the seed."

A. Atterberg[8] carried on experiments with sodium. The fact that sodium is a common constituent of the ash of plants, led the author to test the question whether this element might not be capable of replacing in part other similar plant constituents, especially potash. Two series of experiments were made with black Tartarian oats, grown in pots filled with quartz sand and watered with nutritive solutions containing soluble plant food. Different amounts of potassium were replaced by like amounts

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[7] U. S. Dept. Agr., Div. of Veg. Phys. and Path. Bul. 18.

[8] Sodium as a Plant Nutrient. *Deut. landw. Presse.*, 1881, p. 1035, abstracted *Exp. Sta. Rec.*, 3 : 554.

of sodium in one series and by calcium in another, the latter receiving no sodium. From the outcome of the experiments the author concludes; "These results clearly show that sodium may fill a very important function in case of a deficiency in potassium and that it is therefore not to be regarded as an altogether useless plant constituent."

Extensive field experiments "On the substitution of soda for, and its value in connection with, potash" have been carried on at the Rhode Island Experiment Station[9] since 1894. At the beginning, potash and soda were substituted for each other in different amounts and proportions, on 48 sixtieth-acre plats. Eleven varieties of plants were grown on each plat. The results indicate that soda is inferior to potash, the yields being greater by using potash without soda than by using soda without potash. Where potash in increasing quantities was added to a full amount of soda the yields generally increased; with increasing amounts of soda added to the full amount of potash less satisfactory results were obtained.

In 1895 the results[10] confirmed those of the first year.

The results[11] for 1896 were summarized as follows: "The inferiority of soda in the absence of potash, as compared with potash in the absence of soda, has become more strikingly manifest from year to year, in each of the three years of the experiment. * * * The addition of increasing quantities of potash to the full soda ration has increased the crop, in the order of the increased application of potash in each instance. Soda added to the potash ration has this year for the first time given indications of the probable usefulness, which if not incidental can only become strikingly manifest, if at all, as the depletion of the assimilable potash on the soda plats increases."

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[9] On the Substitution of Soda for, and its Value in Connection with, Potash, H. J. Wheeler, J. D. Towar and G. M. Tucker. R. I. Agrl. Expt. Sta. Rept. 1894, pp. 168–182; abstracted *Exp. Sta. Rec.*, 7 : 849.

[10] R. I. Agrl. Expt. Sta. Rept. 1895, pp. 205–214.

[11] R. I. Agrl. Expt. Sta. Rept. 1896, pp. 221–241.

In 1897 the authors gave a summary[12] of the general results of four years' experiments. "It may be stated at this time that, with each succeeding year, soda when used without potash, has steadily deteriorated in its action when compared with the results from plats manured with potash, but without soda.

"Where the soda has been added in increasing quantities to a full potash ration, little or no benefit from its use has been apparent. On the other hand, the addition of increasing quantities of potash to a full soda ration has, especially in the last two years, been attended with most marked gains."

The results[13] for the year 1898 are stated to "show the marked inferiority of soda when used without potash as compared with potash when used without soda. * * * When the potash supply was reduced to a quarter ration the soda proved quite effective. When the potash supply was equivalent to half and three-quarters rations, the soda seemed to be far less effective than in 1897."

Dr. M. Stahl-Schroeder[14] in 1898 gives the outcome of his experiments and reviews the work of others:

Hellriegel showed that the sugar content of the beet is closely related to the potash content of the fertilizer.

Mathieu de Dombasle claimed, in 1839, that salt had no fertilizing value. Birner and Lucanus,[15] in 1866, on the other hand, found a slight beneficial action. Wolff,[16] 1868, came to the same conclusion, yet states that it might have been possible for the soda used to contain traces of potash.

Deherain[17] stated that soda cannot take the place of potash, but simply has an indirect action by helping to make some of the unavailable potash in the soil available for plant growth.

Jamieson[18] also found that soda cannot replace potash.

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[12] R. I. Agrl. Expt. Sta. Rept. 1897, pp. 226–240.
[13] R. I. Agrl. Expt. Sta. Rept. 1898, p. 137.
[14] *Jour. Landw.*, 47 : 49; abstracted in *Exp. Sta. Rec.*, 11 : 35.
[15] *Landw. Vers. Sta.*, 7 and 8.
[16] *Land. Vers. Sta.*, 10.
[17] *Biedermann's Centralblatt*, 1884, p. 424.
[18] *Biedermann's Centralblatt*, 1886, p. 249.

Pagnoul[19] decided that a plant may take up soda, yet in plants grown with soda, the potash content was three times as large as that of soda. Plants which received only potash contained no soda or at least not more than traces. Oats, he stated, will not take up soda as long as there is potash present, yet in case of a shortage of salts of the latter, soda may have a beneficial action.

Paul Wagner[20] concluded from experimental work that soda may have an essential influence upon the development of the plant, and that the crop may be increased almost one-half by using salt with a potash fertilizer; but it is impossible for soda to perform all the functions of potash in plant growth.

Maercker[21] gave results showing the beneficial action of sodium and magnesium chloride when applied with potash in the Stassford salts.

The author's (Stahl-Schroeder) own work was planned first to gain some light on the question of the presence of soda in plants and second to determine the possibility of partially rep'a·-ing potash by soda in plants.

Working with the oat plant he found soda present in practically all cases even with a large supply of potash in the fertilizer. This was true of roots, straw and grain.

To solve the second question the author resorted to pot experiments growing peas, oats, carrots and buckwheat in Wagner's vegetation pots, using a potash-poor peat soil. All the pots received phosphoric acid, lime, nitrogen and magnesia. In addition two pots in each set received two grams potash and two two grams soda. The increase of the weight of the crop was in all cases so small, when using soda, over the pot receiving neither potash nor soda that the action, either direct or indirect, of the soda is certainly not worth considering.

Chemical analysis of the crops receiving neither potash nor soda showed a low percentage of potash and as a rule a larger percentage of soda. With the pots receiving potash this was

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[19] *Biedermann's Centralblatt*, 1895.

[20] Die Stickstoffdungung der landw. Kulturpflanzen. Berlin : 1892.

[21] *Arbeiten der deutschen Landwirtschafts-Gesellschaft*, 20.

reversed. With the pots receiving soda the proportion of potash was but slightly higher than in the first series, but rather more soda was present. The percentage of lime and magnesia seems to increase with the decrease of potash and *vice versa*.

Dr. Augustus Voelcker,[22] has conducted field experiments with crude German potash salts and common salt on mangolds. Mangolds were grown upon a light sandy soil, the first series of plats receiving no fertilizer, the next common salt and the third crude potash salts, containing 24 per ct. K_2SO_4, 12 per ct. $MgSO_4$, 47.8 per ct. NaCl.

In speaking of the yield the author says:—"Making due allowance for the natural variation in the productive powers of different parts of the same field, common salt, it will be noticed in every instance, gave as good results as an equal weight of the more expensive crude potash salts. The larger dose of salt produced a greater increase than the smaller."

"As the crude potash salts used contained twice as much common salt as sulphate of potash, and common salt gave as much increase as an equal weight of crude potash salts, it is more than doubtful whether the potash in the latter had any share in increasing the crop on the plats dressed with crude potash salts."

A study was made by Smets and Schrieber[23] of the potash needs of various Belgian soils as well as the possibility of the replacement of part of the potash by soda. On some soils the soda seemed to have no action; on others if the potash content was not too small there was an increase of the crop. In the presence of a larger quantity of potash the soda seemed to have no action.

Prof. S. W. Johnson[24] in making what is undoubtedly a very just review of the data bearing upon the use of potassium and sodium by plants, places potassium as among the elements absolutely essential to the life of agricultural plants. Concerning sodium Prof. Johnson says:

[22] *Jour. Royal Agr. Soc.*, 3: 86 (1867).

[23] *Biedermann's Centralblatt*, 28: 227. (1898.)

[24] How Crops Grow.

"1. That sodium is never totally absent from plants; and that

"2. If indispensable, but a minute amount of it is requisite.

"3. That the foliage and succulent portions of the plant may include a considerable amount of sodium that is not necessary to the plant; that is, in other words, accidental."

Concerning the replacement of potassium by sodium the same author concludes "that the sodium which appears to replace potassium is accidental, and that the replaced potassium is accidental also, or in excess above what is really needed by the plant," and leaves us to infer that the quantity of these bodies absorbed depends to some extent on the composition of the soil, and is to the same degree independent of the wants of vegetation.

EXPERIMENTS AT THIS STATION.

These experiments were begun in the winter of 1898-1899 and were continued in the winter of 1899-1900. They were carried on in a forcing house devoted entirely to plant nutrition and were in the immediate charge of Mr. O. M. Taylor, who gave the plants the most painstaking care under conditions such as to insure the experiments against errors and accidents.

THE PLAN AND DETAILS OF THE EXPERIMENTS.

The soil.—Plant feeding experiments with natural soil are in some respects very unsatisfactory. With such a medium for growth, even the most sterile that can be found, it is not possible to control the supply of plant food within desirable limits. On the other hand no perfectly sterile artificial soil has been discovered which presents conditions the most favorable for plant growth.

In these experiments pure quartz sand has been used. This was ground from quartz rock by the Berkshire Glass Sand Co., Cheshire, Mass. The degree of fineness admitted of the sand nearly all passing through a sieve .025 inch in mesh. Tests of this sand for phosphoric acid and potash gave no trace of the former and an average of only .00078 per ct. of the latter.

1

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Complete fertilizer.	Without soda.	Without potash.	Without soda or potash.

PLATE XXVIII.—BARLEY IN POTASH-SODA EXPERIMENTS, 1898-99: FIG. 1, EARLY GROWTH; FIG. 2, AT HARVEST.

Complete fertilizer.	Without soda.	Without potash.	Without soda or potash.

PLATE XXIX.—TOMATOES IN POTASH-SODA EXPERIMENTS, 1898-99: FIG. 1, EARLY GROWTH; FIG. 2, AT HARVEST.

Complete fertilizer.	Without soda.	Without potash.	Without soda or potash.

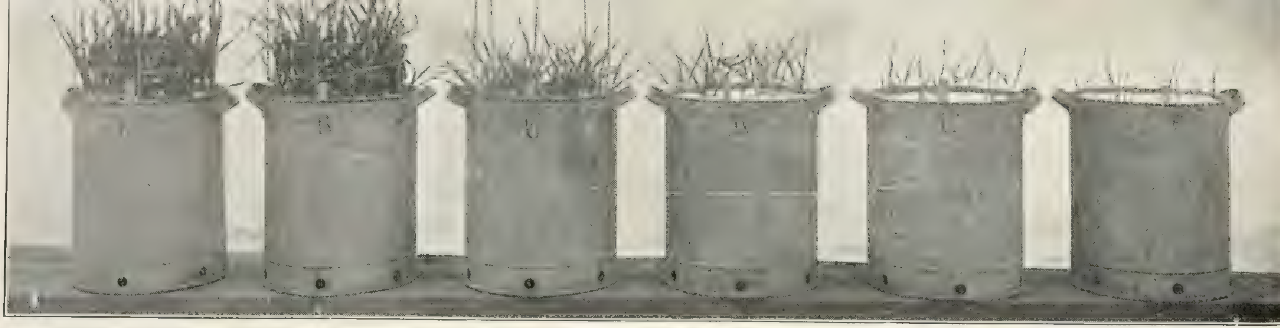
PLATE XXX.—PEAS IN POTASH-SODA EXPERIMENTS, 1898-99:
FIG. 1, EARLY GROWTH; FIG. 2, AT HARVEST.

Complete fertilizer. | Without soda. | Without potash. | Without soda or potash. | Nitrogen only. | Nothing.

PLATE XXXI.—BARLEY IN POTASH-SODA EXPERIMENTS, 1899-1900: FIG. 1, EARLY GROWTH; FIG. 2, AT HARVEST.

Complete fertilizer. | Without soda | Without potash | Without soda or potash | Nitrogen only | Nothing

PLATE XXXII.—PEAS IN POTASH-SODA EXPERIMENTS, 1899-1900. FIG. 1, EARLY GROWTH; FIG. 2, AT HARVEST.



Fertilizers as on Plate IV except Calcium Nitrate used throughout instead of Ammonium Nitrate.

PLATE XXXIII.—BARLEY IN POTASH-SODA EXPERIMENTS, 1899-1900: FIG. 1, EARLY GROWTH; FIG. 2, AT HARVEST.

This material has shown no tendency to agglutinate and with proper water conditions its texture has appeared to offer no obstruction to free root growth.

The pots.—The plants were grown in galvanized iron pots. They contained 25 pounds of sand and 4 to 6 pounds of drainage material, the latter consisting of quartz chips. Aeration was secured by connecting the drainage with glass tubes extending up the side of the pots above the sand.

Kinds and quantities of plant-food applied.—The general scheme of food supply may be easily understood, perhaps, through the following form of statement:

Order in the series.	Method of treatment.
1	Received complete fertilizer.
2	Received complete fertilizer, soda excepted.
3	Received complete fertilizer, potash excepted.
4	Received complete fertilizer, potash and soda excepted.
5	Received only nitrogen.
6	Received nothing.

This arrangement was adopted wholly with reference to studying the influence upon the plant of depriving it of all but a very limited supply of potash, or of soda, or of both potash and soda, when all other compounds necessary for growth were present in sufficient quantities. Outside of these variations, conditions were made as uniform as possible.

The tabular arrangement which follows shows very clearly the kinds and quantities of compounds added to each pot in the series of six.

TABLE I.—KINDS AND AMOUNTS OF FERTILIZING MATERIALS ADDED TO EACH POT.

Order in series.	Acid phosphate.	Potassium nitrate.	Sodium nitrate.	Magnesium sulphate.	Ammonium nitrate.	Calcium carbonate.	Ferric chloride.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
1	7.5	5.0	5.0	2.5	......	5.0	1.0
2	7.5	5.0	......	2.5	2.35	5.0	1.0
3	7.5	......	5.0	2.5	2.00	5.0	1.0
4	7.5	......	......	2.5	4.35	5.0	1.0
5	......	......	......	......	4.35	......	......
6	......	......	......	......	......	......	......

Calcium carbonate was added in a quantity entirely sufficient to neutralize any possible acidity which might arise from the use, by the plants, of bases in excess of the use of acids from the various salts. This caused the reversion of the acid phosphate, of course, but did not thereby render the phosphoric acid unavailable.

In part of the experiments of 1899-1900 the ammonium nitrate was replaced by calcium nitrate. The various salts used were supposed to be chemically pure. It was discovered, when too late, that some of those used in 1898-1899 were not strictly free from potassium, and for that reason in the first year's experiments all of the first four boxes in the series received more or less potassium outside of that derived from the water and sand. In the second year's work the chemicals are regarded as having been strictly free from potassium.

It is not at all certain that the compounds used to feed these plants were the best in kind and proportion that could have been selected for promoting thriftiness of growth. Unquestionably the plants did not thrive as they would under usual forcing house conditions, but whether this was due to the peculiar character of the soil or to a lack of adaptation on the part of the food supply is not known. Probably both factors exerted an influence.

The water.—The water used in these experiments was distilled. It was not entirely pure, however. In the second year's work (1899-1900) the water was taken to the forcing house in twelve large lots and the percentage of potash was determined in each lot. The quantity of potash present was found to vary from .0008 to .0074 gram in ten liters of water, averaging .002 gram. As the amount of water applied per can did not exceed eighteen liters in any case, the potash derived from the water per can was not over .0036 gram. The water was applied according to the judgment of the one in charge of the forcing house.

THE EXPERIMENTAL RESULTS.

The data secured include the growth of dry matter under the various conditions involved and the proportions and quantities of potash and soda in the plants. The difficulties of accurate soda determinations are well understood by chemists. In regard to the figures given herewith it can only be said that all known precautions against error were adopted.

TABLE II.—GROWTH OF PLANTS IN THE POTASH AND SODA EXPERIMENTS, 1898–99.

PLANT FOOD SUPPLIED.	YIELD PER BOX. Number of box.	Fresh. Total.	Fresh. Fruit.	Air-dry total.	PARTIAL COMPOSITION AIR-DRY CROP. Moisture.	Potash. (K_2O.)	Soda. (Na_2O.)
Barley (1).		*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*	*Per ct.*
Complete fertilizer	133	210.	35.5	71.	6.95	1.76	1.85
All but soda..............	134	208.2	42.	72.	7.46	2.27	0.77
All but potash............	135	114.8	13.7	33.	7.63	.39	4.95
All but potash and soda...	136	135.3	21.2	43.	7.75	.43	2.36
Only nitrogen.............	137	7.9	——	3.5	8.38	1.53	1.34
Nothing	138	20.2	1.7	8.	8.08	.69	1.47
Barley (2).							
Complete fertilizer........	139	219.8	33.4	79.	7.75	1.65	1.66
All but soda..............	140	210.2	33.8	79.	7.72	2.18	.63
All but potash............	141	109.6	10.8	34.0	8.59	.36	4.78
All but potash and soda...	142	118.5	28.5	47.	8.68	.27	1.76
Only nitrogen............	143	8.1	——	3.5	8.03	1.35	1.26
Nothing	144	16.	2.	8.0	7.66	.75	1.43
Tomatoes (1).							
Complete fertilizer........	121	512.5	325.	47.	9.08	3.45	1.08
All but soda..............	122	724.	478.	72.	8.38	2.75	.37
All but potash............	123	85.5	——	10.	8.82	.71	2.61
All but potash and soda...	124	79.5	——	9.	8.57	1.35	1.51
Only nitrogen.............	125	.14	——	.02	——	——	——
Nothing	126	.23	——	.04	——	——	——
Tomatoes (2).							
Complete fertilizer........	127	543.	326.5	51.	8.00	3.59	1.21
All but soda..............	128	677.	442.	64.	8.41	2.99	.32
All but potash............	129	167.	42.	20.	8.72	.58	2.30
All but potash and soda...	130	230.	77.	31.	8.46	.57	1.17
Only nitrogen.............	131	.03	——	.02	——	——	——
Nothing	132	.19	——	.04	——	——	——

Plant Food Supplied.	Yield per box. Number of box.	Fresh. Total.	Fresh. Fruit.	Air-dry total.	Partial composition air-dry crop. Moisture.	Potash. (K_2O.)	Soda. (Na_2O.)
Peas (1).		*Grams.*	*Grams.*	*Grams*	*Per ct.*	*Per ct.*	*Per ct.*
Complete fertilizer........	109	249.5	4.5	57.1	6.92	2.34	1.49
All but soda..............	110	285.5	11.3	73.1	6.75	2.33	0.73
All but soda..............	111	176.	15.8	42.5	6.82	.27	2.77
All but potash and soda...	112	187.	13.5	53.3	7.10	.25	1.09
Only nitrogen	113	9.	——	4.	8.90	.41	1.02
Nothing	114	7.1	1.5	3.	8.80	1.12	1.67
Peas (2).							
Coplete fertilizer..........	115	210.	12.	58.	6.99	2.74	1.89
All but soda..............	116	213.5	20.4	66.0	7.19	2.39	.77
All but potash............	117	169.	42.5	54.	8.86	.33	2.29
All but potash and soda...	118	182.	40.	58.	8.49	.37	1.15
Only nitrogen	119	5.3	——	3.	9.65	.55	1.46
Nothing	120	4.8	1.6	2.	9.25	1.28	1.33

TABLE III.—GROWTH OF PLANTS IN THE POTASH AND SODA EXPERIMENTS, 1899–1900.

Plant Food Supplied.	Number of box.	Yield air-dry matter per box.	Partial composition air-dry crop. Moisture.	Potash. (K_2O.)	Soda. (Na_2O.)
Barley (1).		*Grams.*	*Per ct.*	*Per ct.*	*Per ct.*
Complete fertilizer.............	109	54.	5.66	1.75	1.27
All but soda..................	110	56.	5.13	1.74	.20
All but potash................	111	12.	2.98	.07	2.39
All but potash and soda........	112	.10	——	——	——
Only nitrogen.................	113	.17	——	——	——
Nothing	114	1.26	7.31	.65	.70
Barley (2).					
Complete fertilizer.............	115	57.	5.80	1.88	1.51
All but soda..................	116	61.	5.78	2.13	.14
All but potash................	117	5.5	4.46	0.13	3.19
All but potash and soda........	118	.17	——	——	——
Only nitrogen.................	119	.20	——	——	——
Nothing	120	——	——	——	——
Barley (3).					
Complete fertilizer.............	A.	48.5	5.68	1.92	1.64
All but soda..................	B.	50.5	5.61	2.36	0.14
All but potash................	C.	17.	5.42	.10	6.
All but potash and soda........	D.	14.	5.62	.21	.69
Only nitrogen.................	E.	7.	6.01	.56	.27
Nothing	F.	4.5	6.78	.76	.29

Plant Food Supplied.	Number of box.	Yield air-dry matter per box.	Partial composition air dry crop. Moisture.	Potash. (K_2O)	Soda (Na_2O.)
Barley Roots (3).		*Grams.*	*Per ct.*	*Per ct.*	*Per ct.*
Complete fertilizer.............	A.	37.	1.27	.29	.40
All but soda....................	B.	35.5	1.28	.29	.11
All but potash..................	C.	7.5	2.14	.05	.71
All but potash and soda........	D.	9.	1.81	.02	.19
Only nitrogen..................	E.	7.5	1.44	.03	.14
Nothing	F.	3.5	2.45	.08	.18
Tomatoes (1).					
Complete fertilizer.............	127	5.17	5.24	5.12	.28
All but soda....................	128	6.78	5.13	5.50	.23
All but potash..................	129	2.35	5.46	.31	1.77
All but potash and soda........	130	1.50	5.84	.52	.46
Only nitrogen..................	131	.72	7.17	.75	.38
Nothing	132	.27	——	——	——
Peas (1).					
Complete fertilizer.............	133	14.	6.29	4.25	1.62
All but soda....................	134	9.	6.01	5.89	.67
All but potash..................	135	5.5	6.07	.33	2.88
All but potash and soda........	136	2.5	6.33	.55	.20
Only nitrogen	137	1.1	5.54	1.11	.17
Nothing	138	1.8	6.01	.61	.14
Peas (2).					
Complete fertilizer.............	139	15.	6.34	3.42	.40
All but soda....................	140	13.5	6.03	5.78	.58
All but potash..................	141	6.	6.96	.40	1.75
All but potash and soda........	142	3.5	6.26	.65	.24
Only nitrogen	143	1.6	5.70	1.10	.14
Nothing	144	2.1	5.60	.75	.14

In order to present the results reached in as concise and clear a statement as possible, averages derived from the preceding tables are arranged, showing the relation between the way the plants were fed and the yield and composition of the dry matter produced.

TABLE IV.—SUMMARY OF RESULTS FOR 1898–1899.

PLANT FOOD SUPPLIED.	Yield of dry matter per pot.	POTASH. In percentage of dry matter.	POTASH. Quantity taken up per pot.	SODA. In percentage of dry matter.	SODA. Quantity taken up per pot.
	Grams.	*Per ct.*	*Grams.*	*Per ct.*	*Grams*
BARLEY.					
Complete fertilizer	69.5	1.84	1.276	1.89	1.312
Soda omitted	69.7	2.41	1.678	.75	.526
Potash omitted	30.8	.41	.125	5.29	1.629
Both potash and soda omitted	41.3	.38	.156	2.23	.921
TOMATOES.					
Complete fertilizer	44.8	3.85	1.726	1.25	.562
Soda omitted	62.2	3.13	1.947	.38	.235
Potash omitted	13.7	.68	.093	2.63	.360
Both potash and soda omitted	18.3	.81	.149	1.37	.250
PEAS.					
Complete fertilizer	53.5	2.73	1.462	1.82	.973
Soda omitted	64.7	2.54	1.640	.80	.520
Potash omitted	44.4	.33	.146	2.72	1.207
Both potash and soda omitted	51.3	.34	.174	1.22	.624

TABLE V.—SUMMARY OF RESULTS FOR 1899–1900.

PLANT FOOD SUPPLIED.	Yield of dry matter per pot.	POTASH. In percentage of dry matter.	POTASH. Quantity taken up.	SODA. In percentage of dry matter.	SODA. Quantity taken up.
	Grams.	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*
BARLEY.					
Complete fertilizer	50.1	1.96	.982	1.56	.781
Soda omitted	52.7	2.19	1.155	.17	.089
Potash omitted	10.6	.10	.011	4.66	.494
Potash and soda omitted	13.2	.22	.029	.73	.097
TOMATOES.					
Complete fertilizer	4.9	5.41	.265	.29	.014
Soda omitted	6.4	5.83	.373	.25	.016
Potash omitted	2.2	.32	.007	1.91	.042
Potash and soda omitted	1.4	.57	.008	.50	.007
PEAS.					
Complete fertilizer	13.6	4.07	.554	.74	.101
Soda omitted	10.06	6.18	.655	.65	.069
Potash omitted	5.4	.39	.021	2.44	.132
Potash and soda omitted	2.8	.64	.018	.21	.006

CONCLUSIONS.

The conclusion that potash stands in a different and much more important relation to the physiological needs of plants than does soda cannot be evaded, and there is no reason for modifying the deductions drawn from the data of the early investigators.

A discussion of the substitution of soda for potash in plant growth may be answered with reference to (1) substitution in quantity and (2) substitution in function.

Substitution of soda for potash, in quantity.—There is no question but that in these experiments the dry matter of those plants having access to a very limited supply of potash and a free supply of soda contained a much larger proportion of soda than where potash was present in abundance. The percentages of soda where the potash was deficient were from one-half to five times greater than where the salts of both alkalies were liberally supplied. In this sense potash was substituted for soda. Limiting the supply of soda did not effect an equal increase of potash, although there appeared to be a tendency in some instances to substitute potash for soda.

Substitution of soda for potash, in function.—The most important question in this connection is, Did the increase in soda taken up by the plants make good the deficiency of potash by promoting the growth of the plant to the same extent as the potash? In other words, Can soda be substituted for potash in function? This question must be answered in the negative so far as these experiments throw any light upon it, and the results here presented stand in entire accord with the great mass of testimony furnished by previous investigations.

In these experiments the lack of potash was fatal to the vigorous development of the plants. This is especially shown in the results of 1899–1900 where the supply of potash was limited to a very small quantity. While the plant appropriated increased amounts of soda when the potash was deficient, this seemed to be of no avail in making good the lack of potash. On the other hand a lack of soda appeared to be no disadvantage whatever, when potash was present in a sufficient amount.

The necessary proportion of potash.—Observations which the writer has made in watching the growth of plants in pot culture with known supplies of plant food has led him to inquire whether the practice of computing the needs of a crop on the basis of what it contains of potash and certain other ingredients is rational. Does the plant need all the potash it takes up? If not how much does it need? In the experiments of 1898–1899 the peas grew as rapidly and matured as fully with .146 grams of potash per pot as with 1.462 grams. Many facts have come to light which go to prove that the proportion of mineral compounds taken up by plants is much modified by the soil supply of these compounds. This being the case, what is the minimum proportion necessary for the fullest development of the plant? This is an important question. A crop of potatoes may withdraw 100 lbs. of potash from an acre of fertile soil, but if 50 lbs. would have been sufficient it is greatly desirable that the farmer should understand the fact.

This problem is just now the subject of investigation at this Station and it is hoped that by giving it extended study reliable conclusions may be reached.

REPORT

OF THE

Dairy Department.

GEO. A. SMITH, *Dairy Expert.*

TABLE OF CONTENTS.

THE INFLUENCE OF THE TEMPERATURE OF CURING UPON THE COMMERCIAL QUALITY OF CHEESE.*

GEO. A. SMITH.

SUMMARY.

Experiments have been carried on at the Station during 1899 and 1900, in which cheeses cured at temperatures common under ordinary factory conditions were compared with similar cheeses cured at lower temperatures.

Of the cheeses made in 1899 those cured at 60° F. and below scored, on the average, almost 5 points higher on flavor and 2.5 points higher on texture, than those cured at 65° F. and above. In 1900, the average difference in favor of the lower temperatures was 5.1 points on flavor and 2.7 points on texture.

INTRODUCTION.

The importance of the dairy industry in New York has led this Station to devote much attention to questions arising in that great branch of agriculture. One of our leading dairy interests is the manufacture of cheese, this State producing about one-half of the total amount made in the United States. Consequently any change in methods by which the quality of this product is improved or the cost to produce it is lessened, will be of great financial benefit.

In all other lines of manufacture, competition has compelled close study of details to insure economical production of products perfectly adapted to the market sought, each factor being

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carefully examined by itself and in its relation to other factors and to the finished product. In cheese production, however, though it is a manufacturing enterprise and one of great importance, this business-like, systematic study of details has been given by very few makers. It will, perhaps, not appear so strange that such is the case when we consider the development of the cheese industry. The time is not yet very remote when practically all New York State cheese was made in the home dairy, no factories being in existence. Then it would be noticed in a community that one farmer was more successful than his neighbors in handling the milk from his herd, and secured a better price for his products. To avail themselves of this advantage from better management of the milk, these neighbors turned over to this better qualified manufacturer the raw material from their own herds. As the economy in handling products in quantity became apparent, to say nothing of improvement in quality, it led to a rapid extension of the system, until the factory business has grown to its present proportions and home cheese-making has become almost a lost art.

The entire procedure in successful cheese-making has been founded, until within a few years, on tradition and good judgment. Experience rather than a knowledge of principles has been the maker's guide. At first the young man who had worked for that successful dairy farmer long enough to acquire a thorough knowledge of his methods was employed when a new center of cheese-making was established; but the building of new factories soon outstripped the supply of men well prepared to manage them. So long as each factory could get for its head a trained man of good judgment, thoroughly impressed with the necessity of strictly observing the constantly varying conditions of the atmosphere and well aware of the effect of these and other conditions upon the quality of his product, these coöperative factories were fairly successful. When the demand for factories became greater, men competent to manage all of them were not available; and the mediocre cheese-maker, handicapped as he often was by his location in a factory poorly planned and

cheaply constructed, could not produce first-class cheese. Good cheese was still made by the masters of manufacture; but the tendency of the entire output was toward deterioration in quality. This means lessened consumption and lower prices.

These conditions still prevail to too great an extent, though decided efforts have been made within the past few years, and with some success, to restore New York cheese to its position as the standard of quality in the great markets. The object of the Station in publishing this bulletin is to point out at least one weak point in the system of cheese handling as at present conducted and to suggest a possible practical improvement.

EXPERIMENT IN CURING CHEESE.

GENERAL CONDITIONS.

Believing that it would be easy to demonstrate faults in the present system of curing, we have carried on quite extended work along this line. Conditions have been so arranged that cheeses made practically alike could be cured at the temperatures secured under average factory handling and at much lower temperatures. Experiments made elsewhere[1] on a laboratory scale indicated that keeping the cheese comparatively cool during the time of curing would give a better product; and comparison of the many cheeses in our tests, cured at different temperatures, establishes the fact beyond doubt.

Making the Cheese.

The foundation of good dairy products is a healthy cow, in sanitary surroundings, well fed and well cared for, yielding her milk to a clean milker, into clean utensils. These essentials we sought to secure, then aerated and cooled the milk in good, pure air as soon as possible after milking, and kept it till needed in a cool, clean place. In making the cheese the following method was used: As soon as the milk is received in the morning it is heated to 84° and then tested for acidity, using the Marschall

[1] Wis. Agr. Exp. Sta. Ann. Rpt., 1897, p. 194.

rennet test, the showing required in the test cup being four spaces. This indicates an acidity which, under our conditions, will mature the curd sufficiently for drawing the whey in about two and one-half hours. With such an amount of acid at the start, the curd will, at the end of the time given, show one-eighth inch fine threads upon the hot iron.

In very few cases was the milk sufficiently "ripe" immediately after heating to secure the best results as we handle it; therefore, carefully prepared sour milk was added in moderate quantity. By this method the milk in a very short time reaches the acidity required. We believe that, when the milk does not contain quite enough acid, the addition of a sufficient amount of sour milk to secure the proper degree of ripeness quickly is much more satisfactory and safe than holding the milk until the acid develops normally. If gas-forming bacteria are present in abundance, holding the milk allows them to increase and doubles the liability to "gassy" curd. As soon as the milk shows proper conditions by the Marschall test, rennet is added at the rate of 2½ ounces to 1,000 pounds of milk, this amount of good rennet extract being sufficient to coagulate properly ripened milk so that, with intelligent handling of the curd, the loss of solids is as small as possible.

The curd is cut in about 30 minutes from the time the rennet is added, using care to have the pieces of curd uniform in size and fine enough to make a proper separation of moisture easy.

The stirring of the curd commences as soon as the cutting is completed and continues, without increasing the temperature, until the separation of water from the curd is well started. The heat is then gradually increased, taking about one hour to reach the extreme of 98° F. If at this point there is a sufficient separation of water from the curd, so that the latter has a firm appearance and has reached such a stage of contraction that it does not pack, and the heat is uniform throughout the mass, the vat is covered and allowed to stand, the curd being occasionally stirred to prevent matting together and to keep it even throughout. Under these conditions, with proper acidity at the start,

the hot iron test should show one-eighth inch threads in about one hour from the time the extreme temperature of 98° is reached; when the whey should be drawn and the curd piled on the sides of the vat. When this curd has sufficiently matted, it is cut into pieces four or five inches square and turned. The turning is continued at short intervals until the curd is solid and the unassimilated water has been thoroughly drained from it. The curd may now be piled for a short time until it becomes mellow to the touch and has a flaky, fibrous texture. It is now ready to be put through the curd mill, spread out and properly aired, and reduced in temperature to 82° to 84° before salting. Two and one-half pounds of salt is used to 1,000 pounds of milk and the curd allowed to stand until the salt is dissolved and the curd itself becomes silky in appearance; when it is put to press.

The time required for the entire process is from five to five and one-half hours.

The details of the manufacture have been given in full so that those who are familiar with cheese-making may see that the cheeses thus made would promise good results when cured.

They were then placed in the curing rooms at different temperatures and removed at various dates, for scoring.

RESULTS.

In studying the question it was necessary to plan the work so that the differing temperatures in the separate curing rooms should be the only factors not alike in the manufacture and curing of the cheeses compared. The detailed plans of the cheese curing rooms and the method of temperature control have been given in a previous bulletin;[2] so the description will not be repeated here, further than to say that each of the six insulated curing rooms can be kept automatically at a uniform temperature at any point between 40° and 90° F. The refrigeration worked in a very satisfactory manner. In each room cloth is suspended in such a way as to be continuously wet; so that the percentage

[2]Bulletin No. 153 of this Station, pp. 307, 311.

of saturation may be kept as nearly uniform as possible in all the rooms.

Cheese made during 1899.—In 1899 four rooms were used, in which the temperature was kept at 70°, 65°, 60° and 55° respectively. The time of making, date of scoring and the marks given each cheese are shown in Table I, the scale of judging being 50 points for perfect flavor and 25 points for perfect texture. The scoring of June 20 was by M. T. Morgan, one of the experts of the State Department of Agriculture, that of Sept. 5, by judges at the State Fair, and that of Oct. 16 by Jas. A. Brown and Sons of Utica.

TABLE I.—SCORING OF CHEESES CURED AT DIFFERENT TEMPERATURES, 1899.

Cheese made.	Cheese cured at a temperature of 70° F. — Scored. June 20. F.	T.	Sept. 5. F.	T.	65° F. — Scored. June 20. F.	T.	Sept. 5. F.	T.	Oct. 16. F.	T.	60° F. — Scored. June 20. F.	T.	Sept. 5. F.	T.	Oct. 16. F.	T.	55° F. — Scored. June 20. F.	T.	Sept. 5. F.	T.	Oct. 16. F.	T.
March 20.	42	21	40	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March 20[1].	..	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	49	25	...	...
March 22.	..	..	...	...	44	24	44	24	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March 24.	..	..	...	...	...	...	...	...	...	...	49	25	49	25	...	...	...	...	...	...	...	...
March 28.	..	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	49	25	49	25	...	...
April 3.	43	20	...	...	...	...	...	...	...	...	...	...	...	...	...	...	49	25	...	...	...	...
April 14.	45	23	...	...	47	24	...	...	...	...	49	25	...	...	...	...	49½	25	...	...	...	...
April 24.	..	..	42	22	...	...	45	23	...	...	...	...	49	25	...	...	...	...	49	25	...	...
May 31.	46	23	41	20	...	...	...	...	...	...	50	25	50	25	...	...	...	...	...	...	...	...
July 21.	..	..	...	...	...	...	...	...	47	25	...	...	...	...	48	25	...	...	...	...	49	25

[1] Kept in 70° room until April 30.

From this table it will be seen that, without exception, of cheeses made at the same time or a few days apart, those cured at the lower temperatures scored higher. The difference was less in texture than in flavor, but, with the high temperature of 70°, texture also was poor. Taking the average scores of the cheeses cured at 65° and above, and at 60° and below, the latter show a gain of almost 5 points in flavor and 2½ points in texture. Concerning the cheeses made July 31, and later sent to Utica, Mr. Brown, the scorer, says: "The cheeses all good; the 55° F. very fine."

On September 20, 1899, a lot of cheese was made from milk containing 5 per ct. of fat and put in the 55° room. In June, 1900, one of these cheeses was sent to E. J. Burrell, Little Falls, N. Y., to test; and, on June 26, he writes: "I have tested the cheese and can say that it is especially fine. The flavor is clean and nutty, the texture is perfect and the curd breaks down beautifully. If the factory men of the country were to manufacture cheese of this description for home-trade purposes, the sale would be largely increased for home consumption and we practically would be entirely independent of England."

Cheese made during 1900.—During the season of 1900 considerable more cheese was made, with practically the same results as to flavor and texture as in 1899. In August Mr. D. W. Whitmore, 89 Warren street, New York, kindly agreed to score for us several lots of cheese which were to be sent at dates about a month apart through the fall and winter. The cheeses sent upon any date were from the same lot of milk, made at the same time and handled as nearly alike as possible except that each was cured at a different temperature. Mr. Whitmore knew these cheeses only by number, not by the temperature of curing; so was entirely unbiased in his scoring. The comparison of these cheeses is shown by Table II.

TABLE II.—SCORING OF CHEESES CURED AT DIFFERENT TEMPERATURES, 1900.

Cheese. Made.		Scored.		No. 1—80° F.	T.	No. 2—75° F.	T.	No. 3—70° F.	T.	No. 4—65° F.	T.	No. 5—60° F.	T.	No. 6—55° F.	T.
July	27.	Sept.	1.	42	21	43	23	45	23	47	24	48	25	45	25
July	30.	Oct.	1.	42	21	43	22	43	22	48	24	49	24	49	24
Aug.	1.	Nov.	1.	39	20	41	20	43	22	44	24	47	24	47	24
Aug.	3.	Dec.	1.	42	21	44	22	44	22	46	24	49	25	49	25
Aug.	8.	Dec.	31.	38	20	39	20	42	21	44	22	48	24	50	25

Taking the average scores of the cheeses as given in this table, those cured at and below 60° show a commercial scoring 5.1 points better in flavor and 2.7 points better in texture than those cured at 65° and above.

Concerning the shipment of September 1, Mr. Whitmore says: "No. 5 is especially fine; No. 6 very good, but the flavor not quite perfect, being a little sharp." This was unquestionably due to the slower curing at the low temperature, the cheese not having quite time enough to ripen fully in five weeks at 55°. Of the next lot, the scorer says: "There is no question but what Nos. 4, 5 and 6 are of a better quality from a commercial standpoint than Nos. 1, 2 and 3. Considering the time when they were made we think they have held very well indeed." In his letter referring to the lot made August 1, Mr. Whitmore says: "Nos. 1, 2 and 3 of this lot of cheese are rather inferior to any you have previously sent me, especially No. 1. If these cheeses were made from the same vat it is almost impossible to comprehend how there can be so much difference in the curing, as Nos. 4, 5 and 6 are of very good quality." Writing concerning the cheeses sent December 1, the comments are: "Nos. 5 and 6 are very nearly perfect cheeses. Considering they were made four months ago, we might say no cheese could be made that would show better at the expiration of that time." Of the last lot Mr. Whitmore's letter says: "Nos. 1 and 2 are about the poorest we have had from you and Nos. 5 and 6 the best, particularly No. 6. This we call, so far as flavor and texture are concerned, a perfect August cheese. It would seem that the results secured with all these different cheeses which show prac-

tically the same thing, namely, that the same cheese uniformly shows a loss of quality from curing at the high temperature and uniformly holds flavor and texture in the lower temperature, being nearly perfect cheese at the end of five months, should convince the producer of the desirability of making the conditions for curing the cheese much more favorable than is the rule at the present time."

Prof. Robertson, of Canada, in his address to the State Dairy Association at Watertown, said that in the Canadian experiments recently conducted, they had secured practically the same results as those here reported, and that Canadian manufacturers are working to improve their factory curing rooms. By lining the rooms with building paper and by ceiling them some improvement was secured; but when there was added a cold air duct the gain was marked. This duct is placed deeply enough in the ground and made long enough so that the air is decidedly cooled before its introduction into the curing room; and the temperature is thus materially reduced.

The cheese cured in such rooms is of enough better quality to secure an advanced price; and the gain in selling value of the product of one year more than repaid the cost of the improvements. With these facts before him the cheese-maker ought not to hesitate long before planning some means of securing lower temperatures in his curing rooms than those now commonly the rule. The improvement presents only a simple question of profit and loss; for cheese of good quality cured as were those in our 60° room must please the consumer and thus add to the demand for cheese and increase its price.

REPORT

OF THE

Department of Entomology.

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[2]Appointed August 1, 1900.

MISCELLANEOUS NOTES ON INJURIOUS INSECTS.*

V. H. LOWE.

SUMMARY.

The forest tent-caterpillars were again very abundant during the spring of 1900, causing serious injury to forest, shade, and fruit trees. Arsenite of lime, arsenate of lead and Paris green were successfully used in combating them. The application was more effectual when made soon after the caterpillars had hatched than after they had become half grown. In villages and cities they were dislodged by streams of hydrant water and prevented from returning by sticky bands or other obstructions fastened about the trunks of the trees.

In some sections of the State the fruit bark-beetle has caused serious injury by working in the bark of healthy fruit trees, especially peach, cherry and plum. The numerous punctures caused a copious exudation of sap. This injury was noticed about the first of August. Eggs and larvæ were found late in the fall in the small twigs and branches. Much can be done toward controlling the insect by applying a wash to the trunk and larger limbs late in July and trimming out and burning the infested branches during the winter.

A species of mealy-bug was found on quince trees in sufficient numbers to cause slight injury. It can be successfully combated by applying a solution of whale oil soap, one pound to five gallons of water.

* Reprint of Bulletin No. 180.

Two species of apple leaf miners were unusually common in Western New York orchards, but caused little injury as they do not appear until late in the season.

Peaches in an orchard near Rochester were injured by the tarnished plant-bug, which sucked the juice from the young fruits, causing them to wither and become permanently distorted.

I. THE FOREST TENT-CATERPILLAR.

Clisiocampa disstria Hubn.

The forest tent-caterpillars appeared again last spring in sufficient numbers to cause much annoyance, and in some cases serious loss. The questions as to whether the caterpillars appear to be increasing or decreasing in numbers, taking the State as a whole, and whether they are becoming more destructive to orchard trees are of importance to fruit growers. To secure data bearing on these questions, circular letters were sent, as last year, to correspondents in nearly every county in the State. Summing up the reports and adding our own observations, the extent and character of the outbreak were approximately as follows: In most of the western Counties the caterpillars were widely scattered, the same as last year. In Allegany and Steuben Counties, they were less in numbers, as a rule, in the maple groves, woodlands and orchards that were extensively infested last year; but much more abundant in neighboring localities in which they appeared in less numbers the year previous. The reports from Cortland, Chenango, Madison, Oneida and Herkimer Counties state that the caterpillars were usually more numerous in the forest trees and orchards than last year but less in numbers on shade trees. The reports from Herkimer County indicate that in that section they were somewhat less abundant in forest trees, but more numerous in orchard trees. Similar reports came from Saratoga and Washington Counties and the Mohawk and Upper Hudson valleys. In the northern part of the State, especially St. Lawrence, Franklin and Clinton Counties, there is a reported decline in numbers.

Destructiveness in the orchards.—Two of the questions asked in the circular letters related to the food plants of the caterpillars and the extent of their injury in the orchards. Similar questions were asked last year and the majority of the replies were to the effect that the caterpillars fed principally upon maple, basswood and elm. This year, while they have been very destructive to forest trees, there were more reports of their depredations in orchards than formerly. During the season we have also received more letters, usually accompanied by specimens, from fruit growers complaining of this insect. In the vicinity of Geneva they have been noticeably more numerous in the orchards this year than last.

There seems to be little preference as to the variety of fruit. Apple, pear, peach and plum have been attacked apparently with equal readiness.

Taking the State as a whole the reports indicate that the caterpillars were usually less destructive to shade and forest trees, but somewhat more destructive to orchard trees.

New localities reported.—The localities not recorded in our Bulletin 159 of last year, but from which reports have been received this year are as follows: Niagara County, Middleport; Monroe County, Spencerport; Allegany County, Andover; Oswego County, Pulaski; Madison County, Oneida, Erieville, West Eaton, De Ruyter and Webster; Otsego County, Westford; Oneida County, Maynard; St. Lawrence County, De Kalb; Franklin County, Fay; Saratoga County, King's Station; Greene County, Coxsackie, West Coxsackie and Cornwallville; Dutchess County, Millbrook; Orange County, Montgomery and Blooming Grove; Westchester County, Bedford Station and Unionville.

Orchards easily infested.—Orchards situated near woodlands are especially in danger of becoming infested because both caterpillars and moths from the groves can easily reach them. A number of cases of this kind have come under the writer's observation. The trees in the rows nearest the woodland were so close that the caterpillars easily migrated to orchard trees from near-by forest trees which they had stripped bare. In this

connection the following extract from a letter from Mr. A. R. Eastman, of Waterville, Oneida County, who has observed this insect closely, is of interest. "The forest tent-caterpillar was far more numerous this year than last in the forests and orchards (about Waterville), not so many in the village. Last year they fed almost entirely on the maple, this year they made no distinction. All kinds of forest trees were attacked. If there were apple trees near the forest the caterpillars seemed to know it for I have seen tens of thousands of them traveling on the fences, even wire fences, leading to the orchards."

Migration in the caterpillar stage is not the only means of local distribution. Probably the species spreads more rapidly through the agency of the adults which are vigorous fliers. The eggs also may be carried long distances upon young nursery trees without injury.

Life history.—The life history of this insect is given in Bulletin 159, pages 40–50, but a brief summary will be of value here to again call attention to the principal points in its development and their relations to methods of control.

This insect, like very many others, passes through four well defined stages: Egg, larva, pupa and adult. The eggs are laid in bands about the twigs (Fig. 8), during the latter part of June or early in July. They remain unhatched on the trees until the following spring, when the young caterpillars appear. Toward the last of May or early in June they reach full growth, stop feeding and wander about to find a convenient place in which to spin their cocoons. Some of them are spun upon leaves, others in protected places on the trunk, in the grass, along fences or upon out-buildings. The moths appear during the latter part of June or early in July and the eggs are laid at once, thus completing the life cycle.

The larva, the pupa and the adult stages are shown in Plates XXXIV to XXXVI as follows: Plate XXXIV, Figs. 1 and 2, are from photographs from life showing dorsal and lateral views of the same caterpillar, natural size. Plate XXXV, Fig. 1, is from another view of the same twig taken the following day.

The leaves which had begun to droop were utilized in forming the cocoon. Plate XXXVI, Fig. 1, is from a photograph of the same cocoon taken the next day. The leaves have been cut away showing the cocoon. It was supported on all sides by strands of silk but did not touch the leaf at any point. The caterpillar was still working on the inside of the cocoon when this picture was taken. The picture shows the cocoon enlarged to about four times natural size, the actual length being about one inch. Plate XXXVI, Fig. 2, is from a photograph of the same cocoon taken three days later. It has been cut open showing the living chrysalis inside enlarged in the same proportion. Plate XXXV, Figs. 1^1 and 1^2, are from photographs from life showing the male and female moths, natural size. At Fig. 2 some of the caterpillars are shown assembled on the trunk of a plumb tree. They had molted a short time before the picture was taken and their old skins are seen to the right of the group attached to the bark.

NOTES ON METHODS OF COMBATING THE FOREST-TENT CATERPILLAR.

The principal methods of combating this insect are given in Bulletin 159, pages 53-56. The following notes are largely from the past season's observations.

ORCHARD TREES.

Destroying the egg masses.—This is most conveniently done while pruning the trees. In the vicinity of Geneva and in other sections of the State this method has been practiced extensively. One orchardist sent his men through a large plum orchard a second time in search for egg masses of both the forest and apple tree tent-caterpillars with the result that a large number were collected and when spring came hardly a caterpillar of either species could be found in the orchard. The year previous this orchard was badly infested with both species.

Banding the trees.—This is principally a preventive but to some extent a remedial measure. Trees that are small enough to be jarred are banded to prevent the dislodged caterpillars

from crawling back. Fruit trees located near infested forest or shade trees are also banded to prevent invasion by the caterpillars. The bands in use are of two kinds: *First*, sticky substances that will not harden too quickly. Prominent among these are a mixture of tar, one part, and raw oil, two parts; raupenleim; and a mixture of lard and sulphur, equal parts. To prevent injury to the bark these substances should be smeared on strips of tough paper a foot or more wide and tied about the trunk about midway between the ground and large limbs. Sticky fly paper is often used in a similar manner. *Second*, mechanical obstructions such as a band of cotton wool or waste, or a strip of tin fastened around the trunk so that the lower edge flares out about two inches, thus preventing the caterpillars from passing. The insect traps made on the same principle and now on the market will answer the same purpose.

Too much should not be expected of the bands as they are of value only in keeping out caterpillars which may crawl from other trees or which have been jarred out or otherwise dislodged from the tree and seek to return.

A very common mistake is to put the bands on too late in the season. If the intention is to prevent an invasion from infested trees near by, the bands should be put in place not later than the middle of March.

Spraying.—Thorough spraying with pure arsenicals has proven very satisfactory in cases where the poison was applied before the caterpillars were half grown. When the first application is delayed until they are past this point it seems to have much less effect. Paris green, arsenite of lime and arsenate of lead have been used. While both Paris green and arsenite of lime have been reported satisfactory, arsenate of lead has some points of especial merit. It seems to be more certain in its action and adheres to the foliage longer. This arsenical is now on the market; but can be made at home by following the directions given in Bulletin 159. It is manufactured by the Bowker Chemical Company, Boston, Mass., The Alder Color & Chemical

Company, New York, and other manufacturers of arsenical compounds.

In a few cases where arsenical spraying had been delayed until too late for best results, kerosene oil was applied directly to the caterpillars that had assembled on the trunks and branches as shown at Plate XXXV, Fig. 2. This treatment was resorted to in several localities in the central and eastern part of the State with satisfactory results. But very little oil should be used as there is danger of injuring the bark and but little is needed to kill the caterpillars.

SHADE TREES.

Owners of shade trees in villages and cities have successfully protected their trees by dislodging the caterpillars with streams of hydrant water and preventing their return by placing bands of cotton batting, sticky fly paper or other obstructions around the trunk. In some cases large shade trees were sprayed with arsenate of lead or Paris green by means of steam sprayers. Both are effectual if applied before the caterpillars are half-grown. Arsenate of lead is discussed more in detail under orchard treatment.

MAPLE GROVES AND FOREST TREES.

The infested maple groves and large forest trees present the most difficult problems. Probably very little can be done. In some cases, however, large numbers of the caterpillars have been killed when assembled on the trunks and lower branches by spraying or otherwise applying a small amount of kerosene oil.

The cocoons are conspicuous and easily gathered, especially where the trees have been stripped of their leaves, as most of the caterpillars desert such trees and spin their cocoons near or upon the ground. The offering of prizes to children for the greatest number of cocoons collected in a given time or the payment of a small sum per thousand has been found in some instances a cheap and easy method of securing the destruction of large numbers of cocoons. They should be gathered as soon

as found after the caterpillars leave the trees. Ten days later the moths will have escaped, and hence it will not pay to gather them after that date.

As soon as gathered the cocoons should be placed in a box and covered with a coarse wire net to allow the parasites to escape. The imprisoned moths will soon die or may be killed by sprinkling a little kerosene oil in the box.

On the whole the season's experience indicates that except when attacking forest trees, the insect is not more difficult to control than many other noxious species. But as with other insect pests prompt and thorough treatment is necessary.

II. THE FRUIT BARK-BEETLE.

Scolytus rugulosus Ratz.

Late in July of the past season Mr. F. C. Stewart of the Station staff brought into the laboratory several small branches from a healthy cherry tree showing the work of some insect. The location and extent of the injury was plainly indicated by the dead leaves. On all of the twigs from one-fourth to about three-fourths of the leaves were brown and dead—in sharp contrast to the remainder which were of normal green color. Plate XXXVII, Fig. 1, is from a photograph of one of these branches. All of the leaves on the lower half were dead. An examination showed that in each spur bearing the dead leaves a small round hole about the size of the head of a pin had been bored as shown, enlarged about four times, at Plate XXXVII, Fig. 2. In each case the hole opened into a short burrow in the sapwood. About forty burrows were examined at this time. All but three were empty, and in these the cause of the injury, some fruit bark-beetles, *Scolytus rugulosus*, were found still at work. Later investigations in the vicinity of Geneva and in Monroe and Niagara Counties showed that this species has caused extensive injury during the past season to healthy, vigorous trees.

Although this species has been long known as an orchard pest it has been supposed to confine its attacks principally to weak,

sickly trees thereby hastening their death. The fact that it will attack and greatly weaken normal trees, as shown on a subsequent page, adds much to its importance as a noxious species.

The following account of observations during the past late summer and fall is preliminary to a more complete account to be published later. Especial attention is called to the character of the insect and the injury caused by it, by which its presence can be easily recognized, and the measures which can be taken this winter to hold it in check.

OBSERVATIONS ON THE WORK OF THE BEETLES IN HEALTHY TREES DURING LATE SUMMER AND FALL.

The work of the beetles at this time of year is of a two-fold nature. First, they make shallow holes or short galleries in the thick bark of the trunk and large limbs apparently to feed and prepare for hibernation. These injuries cause a copious exudation of sap and consequent weakening of the tree. Second, longer galleries are formed in the sapwood of the smaller limbs and twigs in which the eggs are laid. Occasionally shallow holes are also made in the branches and twigs.

Injury to the bark of the trunk and large limbs.—The most pronounced injury to the trunk and large limbs which has come under observation was in three large peach orchards near Youngstown, Niagara County. At the beginning of the season all three orchards were in a healthy, vigorous condition. Two were composed principally of Early and Late Crawfords and Reeves Favorite, the third, recently come into bearing, almost entirely of Globe. About the first of August sap was seen to be exuding from many of the trees. By September 20, when they were first seen by the writer, the trunks and large limbs of many of the trees were covered with sap. Plate XXXVIII will give some idea of the flow of sap from the wounds made by the beetles. This plate is from a photograph of a piece of bark cut from the trunk of one of the peach trees in the orchards above referred to. It is not an extreme case, but from an average specimen.

The most extensive injury was in the Crawford and Reeves Favorite orchards. In these orchards nearly every tree was infested to an equal or greater extent than the piece of bark shown in the photograph. The Globe orchard was of especial interest as it had become infested in one corner from a nearby brush pile, in which the beetles had been breeding, and the rapid spread of the insect through the orchard was plainly indicated.

Character of the channels in the bark of the trunks and lower limbs. Feeding habits of the beetles.—On September 20, pieces of bark from a number of the infested peach trees were examined. Probably owing in part to recent rains the sap was very soft. Comparatively few beetles could be found, and judging from the lack of dust, only an occasional one had been recently at work. Pieces of bark containing beetles were brought to the laboratory, some of them allowed to dry and others were kept moist for a few days. It was very noticeable that as soon as the bark became somewhat dry the beetles began feeding, while there was very little evidence of activity on the part of the beetles in the moist pieces. As soon as the pieces that had been kept moist were allowed to dry the beetles began to work. All of the mines in the bark examined September 20 were very irregular but with few exceptions, short.

In October the orchard was again visited. At this time the bark was comparatively dry, and most of the sap had dried down until quite brittle. All over the infested areas the red dust was in abundance, and when the bark was cut away the beetles were found at work making new galleries or extending the old ones. The galleries ran in all directions but very few of them reached the sap wood.

As on September 20, large pieces of bark were brought to the laboratory and carefully examined for eggs or larvæ. Neither were found, although the beetles were present in large numbers.

Very few of the small branches and twigs of any of the trees in these orchards or in nearby orchards showed the work of the

insect. In every case it was confined almost entirely to the trunks and lower limbs.

Only peach trees were severely injured. Plum and apple trees in the immediate vicinity were uninjured.

Indications of injury to small branches and twigs.—Injury to the small branches and twigs was indicated in two ways: First, by the dead leaves caused by the beetles boring into the buds, Plate XXXVII, Figs. 1 and 2; and second, by the drops of sap that exuded from the burrows in the sapwood, as shown natural size at Fig. 3.

As previously stated, very few of the peach trees in the orchards near Youngstown that were infested on the trunk and branches showed any evidence of the insects' work in the smaller branches and twigs. On the contrary, the peach, plum and cherry trees examined, both in Monroe County and at Geneva and vicinity, were very slightly infested except in the small branches.

Character of the channels in the small branches.—These burrows were of two kinds, the very short ones which were mere punctures of the thin bark and the larger ones through the bark and for from half an inch to an inch in the sap wood. In some cases from two to nine punctures leading to each burrow were found. Many of these burrows, opened September 20 and later, were empty, others contained eggs; and in a few cases young larvæ were found.

NOTES ON LIFE HISTORY.

Observations upon the egg laying habits.—Eggs were first found September 24, by Mr. P. J. Parrott while examining an infested plum tree. Upon subsequent examination of infested plum and peach twigs many of the burrows were found to contain eggs. The number of eggs varied from one to twelve. Nine was the largest number of unhatched eggs found, but in one burrow Mr. Parrott found twelve young larvæ, indicating that twelve eggs had been deposited there.

The eggs were usually placed on end, apex down, close together but were prevented from touching by a layer of gummy shavings which extended around each egg. In every case the rows were single and extended along one or both sides of the burrows. The sticky substance which covers the eggs causes the gummy shavings to adhere to the shell and when dry to hold them firmly in place. In some cases where only three or four eggs were found, there was apparently no definite arrangement, the eggs being scattered through the gummy mass. In no case were they found in definite pockets along the sides of the burrow. Plate XXXVII, Fig. 4, is from a photograph of a burrow cut open showing a row of eggs along one side. Only the ends of the eggs are visible. The whole is enlarged to about three times natural size.

There are some variations in the size of the eggs. One selected as being of average size measured .564 mm. by .4 mm. They are elongate oval in outline, dull white in color with a delicate membranous shell covered with a thin coating of a transparent sticky substance. Plate XXXVII, Fig. 5, is from a photomicrograph showing one of the eggs much enlarged.

The exact period of incubation has not been determined. A number of eggs found in the channels September 24, hatched September 25.

Observations on the late broods.—The number of broods for the latitude of Western New York has not been determined. Large numbers of beetles having the reddish-brown color, characteristic of those newly hatched, were found in the bark and twigs late in September. Larvæ and pupæ were also found and in one instance a number of them brought into the laboratory transformed to beetles by October 15.

Laboratory and insectary observations.—A study of the life history of this insect is now being made. Trees in the laboratory, insectary and orchard are being kept under observation. Young healthy plum trees kept in the laboratory and insectary have been infested in three ways as follows: First, fourteen beetles

were placed upon the trunk and allowed to crawl about. Nearly all of them selected rough places in the bark and immediately began to burrow in. Second, twenty beetles were placed near the ends of the small limbs and prevented from escaping by glass flasks placed over the ends and stopped with a plug of cotton wrapped about the limb. In most cases the bottom of the flask was broken out and a fine wire net fastened over to allow circulation of air and prevent accumulation of moisture on the inside of the glass. Third, sixty-seven beetles were confined in cells made of half-inch curtain rings fastened together and to the bark by melted paraffin. When the beetles had been placed in the cells a thin cover glass, the same as used in microscopic work, was sealed on with paraffin. From one to four beetles were placed in each cell. This method, first suggested by Mr. Parrott, proved to be the most satisfactory as nearly every beetle began at once to burrow into the bark and none of them were lost. A photograph of some of the cells attached to the trunk of a young plum tree is shown at Fig. 9.

Activities of the confined beetles.—The amount of time required for the beetles to bury themselves in the bark varied from about an hour to three hours or more. Whether the beetles will deposit eggs in these young trees and beetles mature, it is too early yet to determine. On November 18, some of the channels were cut open. They were very irregular and extended in all directions. No eggs or larvæ were found.

Hibernation of the beetles.—At the time of writing, Nov. 18, a large number of examinations of bark and branches have been made. As previously stated only beetles were found in the bark of the peach trees evidently preparing to hibernate. The eggs and larvæ in the twigs would indicate hibernation in the larva or adult stage.

The adult.—The adult is a beetle measuring from 1.5 to 2.2 mm. in length and varying in color from reddish-brown to nearly black. The beetles move about quite rapidly and fly readily.

TREATMENT.

Sources of infestation.—The insect breeds readily in dying and dead wood. Weakened trees, especially peach, plum and cherry, often harbor the beetles and if not removed may cause the infestation of neighboring trees. Small branches trimmed from the trees may become the sources of infestation. A case in point is the orchard of Globe peach trees near Youngstown, previously referred to. Without doubt this orchard became infested from a large pile of dead branches within about a rod of the corner tree in the northwest corner of the orchard. The beetles were breeding in the branches early in the season. During August about twenty trees in the corner of the orchard nearest the brush pile were found infested, the presence of the beetles being indicated by the exudation of sap. The worst infested trees were nearest the brush pile.

Suggestions for late summer and winter treatment.—The habits of the beetles, when attacking normal trees, suggest two methods of treatment: First, the liberal application, about the middle of July, of some caustic wash, such as a solution of whale-oil soap, two pounds to the gallon of water, with the addition of crude carbolic acid, two ounces to the gallon of the soap solution. The whole should be well stirred before using, as otherwise the carbolic acid and soap solution will not mix well. Probably two applications about ten days apart will be sufficient. The object of the applications at this time is to prevent the beetles from going into the bark. Second, severe winter pruning. This is to destroy the eggs and hibernating larvæ and beetles in the twigs. The infested branches can be distinguished by the exudation of sap as shown at Plate XXXVII, Fig. 3. The pruned branches should be burned.

III. A MEALY-BUG ATTACKING QUINCE TREES.

Dactylopius sp.

Late in April of last season a quince twig infested with a species of *Dactylopius* was brought into the laboratory. The bearer stated that the insect was first noticed about three weeks previous. On April 27, the orchard was examined. It is one of the largest bearing quince orchards in the vicinity of Geneva, and is situated in an exposed position on the west shore of Seneca Lake. Nearly all of the trees were infested, especially those along the north side, but none of them sufficiently to show injurious effects.

Notes on life history and habits.—On the date above given the mealy-bugs were crawling about on the small branches and twigs or had settled down in protected places in the angles or near the buds. Most of them were from one-third to two-thirds grown. A few adults were found under the loose bark of the trunk and large limbs, but no eggs.

June 28, the orchard was again visited. The twigs were infested about as in April. On this date however, large numbers of adults were found under the loose bark making cocoons and laying eggs. As a rule they were in groups of from two to six or eight as shown at Plate XXXIX, Fig. 1. This picture is from a photograph from life showing the insects enlarged to about four times natural size. Some of them are partially covered by their cocoons. A few eggs are scattered about. From this date until the middle of August there was little change in the numbers. From the middle to the latter part of August there was a decided decrease in numbers. By the first of September very few were left on the twigs. Nearly all of those that remained sought shelter under the loose bark. By September 26, the numbers had diminished materially. Those remaining were from half to two-thirds grown. A few larvæ were found.

October 26, which was an unusually bright, warm day for that season of the year, the mealy-bugs were crawling about freely.

Some of them still remained inactive under the bark. Careful search was made for eggs with the result that one cocoon containing eight eggs was found. Four of the eggs hatched in the laboratory, November 19; the remainder did not mature.

The egg.—The eggs are at first nearly white but finally change to a deep pink. The shell is membranous and covered with a white powder. An egg of average size measured .47 mm. by .23 mm. In shape they are oblong, slightly oval and broadly rounded at both ends.

The eggs are laid in cocoons of coarse silk placed under the loose bark. There is apparently no regularity in their arrangement in the cocoons. An abundance of white powder covers each one and may prevent their touching.

The egg cocoon consists of two distinct parts, an outer coarse tent-like structure of coarse strands of white silk loosely woven and an inner cocoon-like structure more closely woven. The two are connected only by loose strands of silk. The inner structure is oval in shape and contains the eggs. It varies in size but measures on the average about 2 mm. by 5 mm. The cocoon is at first pure white and a beautiful object, but exposure to the weather finally changes it to a dull slate color. The average number of eggs in a cocoon was not determined. One examined contained eight. A cocoon showing inner and part of outer structure is shown natural size and enlarged at Plate XXXIX, Fig. 2.

The larva and adult.—The larvæ closely resemble the adults. When first hatched they are deep pink, and within a few days become covered with a white powder. They are very active and move readily about on the bark. In all stages the insect feeds by sucking the sap from the bark. None were found on the leaves either in the larvæ or adult stages.

The adults are active, soft-bodied insects measuring 3.5 by 2 mm. The color of the living adult is a dull dark green, covered with white powder similar to the larva. As with other species of this genus the margins of the body are irregular, each segment

bearing short, irregular projections. Plate XXXIX, Fig. 3 is from photographs from life showing a single individual enlarged and a group natural size.

Economic importance.—Mealy-bugs are capable of inflicting injury to the host plant in a manner similar to scale insects by sucking the sap from the bark and leaves. A number of species work upon the roots of plants. In the infested quince orchard some injury was undoubtedly done, as the insects sucked the sap from the limbs and twigs often from near the base of the buds. In this case the amount of injury is only a question of numbers.

Treatment.—As the insect is soft bodied, similar to the plant lice, and during the spring and early summer lives openly on the twigs, one or two applications of whale-oil soap, one pound to five gallons of water, would quickly check it. Scraping the trunk and large limbs during the winter where there is loose bark and painting with a strong solution of whale-oil soap, one pound to the gallon of water, would have a similar effect.

IV. TWO APPLE LEAF MINERS.

The minute caterpillars that mine into leaves are among the most common of the insect pests. A number of species work in the foliage of apple trees, but seldom in sufficient numbers to do serious injury. The past season, however, has been an exception in Western New York with at least three species, two of which are briefly discussed here. The two species have occurred in sufficient numbers to cause apprehension on the part of fruit-growers in the western part of the State. Fortunately they do not appear in very large numbers until late summer or fall when most of the leaves are mature, thus making less injurious the work of the caterpillars.

ORNIX PRUNIVORELLA Cham.

Order *Lepidoptera*. Family *Tineidæ*.

This species is probably widely distributed in Western New York, but judging from the few references in the literature of

economic entomology seldom occurs in sufficient numbers to attract much attention. One of the earliest references is by Brunn[1], who in 1883 found it in apple leaves in Tompkins County, but not in sufficient numbers to do material injury. During the past season we have received specimens from Monroe and Orleans Counties. Its distribution in the United States is indicated by Forbes' report[2] in which he states that it is widely distributed in Illinois, and in addition to New York is found in Colorado, Kentucky, Michigan and Massachusetts.

Appearance in Western New York in 1900.—This species was first brought to the writer's attention early in October, when some infested leaves were received from Brockport. The correspondent stated that nearly all the apple orchards in the vicinity of Brockport were badly infested. October 29 an infested apple orchard at Albion was examined. On nearly every tree two-thirds or more of the leaves were distorted by the mines of the larvæ. In many of the leaves from two to four mines were found. Most of them were old, indicating that the larvæ had been working in the leaves several weeks. The owner of the orchard stated that he had first noticed them about the middle of October. In the vicinity of Geneva a number of apple orchards were mildly infested, but no case of serious infestation was found.

Notes on life history and habits of the larvæ.—The life history of this species has not been fully determined. Probably the most complete account is by Forbes,[3] who states that the eggs are laid on the leaves, and that the young caterpillars feed on the parenchyma. When full grown they leave their old mines and form new ones in which to pupate and pass the winter. No description of the egg is given, and the time of egg laying is not stated. No eggs were found on the branches received, and, although a careful search was made, none in the orchards at

[1] Cornell Univ. Agr. Exp. Sta., Second Ann. Rept. (1883), pp. 155–157.

[2] Fifteenth Ann. Rept. State Ent., Ill., p. 59.

[3] Fifteenth Ann. Rept. State Ent., Ill., p. 57.

Albion or Geneva. Some indications of the time of egg laying were given by the evident age of some of the larvæ found October 29. An occasional one less than half grown was found, but most of them were full grown and a number had transformed to pupæ.

The mine.—The young larvæ feed upon the parenchyma usually in the upper side of the leaf. The skin is left intact. The final result is a tentiform mine, which distorts the leaf as shown at Plate XXXIX, Fig. 4. In this mine the larva lives and feeds until full grown. Evidently no attempt is made to keep it clean, as the droppings were always found scattered about, as shown at Plate XXXIX, Fig. 2. This picture shows one of the mines cut open and much enlarged.

When full grown they leave the old mine to prepare for pupation. The manner of doing this is shown by a number of full grown caterpillars which were placed on fresh leaves in the laboratory October 31. They did not mine into the tissue, but selecting the slightly curled edges of the leaves and placing the body in a position nearly parallel to the side and far enough away so that by bending the anterior two-thirds of the body the head would touch the point of one of the serrations, begin to spin strands of silk from this point to the main body of the leaf. There were eight caterpillars, and all of them followed this plan. At Plate XL, Fig. 1, a single point is shown, much enlarged, held by the threads. The larvæ worked very rapidly. In about half an hour most of them had made a network of silk extending about half an inch along the sides of the leaves. They then began to work from the under side of the silk, and as they clung to it began to spin as before. Brunn[4] suggests that the weight of the caterpillar's body causes the margin of the leaf to bend over. This undoubtedly has some effect, but as the caterpillars feed on the parenchyma, under the tent, the withering tissues may play an important part in producing the desired result. In about three hours most of the tents had the appear-

[4]Second Report Cornell Univ. Agr. Exp. Sta., p. 151.

ance of the one shown at Plate XL, Fig. 2, and by the second day all were drawn over as shown at Fig. 3. The caterpillars thus roll the leaves in a manner somewhat similar to a true leaf roller. They evidently feed for a time in these retreats before pupating, as out of a large number examined the parenchyma on the upper side was entirely eaten away in most cases.

Before pupating the caterpillars line their retreats heavily with white, closely woven silk. Every one examined both in the laboratory and in the orchard was lined in this way. The silk is not closely attached to the leaf except at the edges which are fastened together and to the leaf tissue. Within this snug retreat the chrysalis is formed. At Plate XL, Fig. 4, the edges of the leaf that were drawn together have been pulled apart, exposing the white, cocoon-like covering of the chrysalis. In this stage the insect evidently passes the winter, although it is probable that some of the larvæ hibernate, as Forbes[5] states he has found them as late as the middle of November. Our own observations are similar to those of Forbes, as we found hibernating larvæ Dec. 1.

The full-grown caterpillar.—A full-grown caterpillar is shown much enlarged at Plate XL, Fig. 5. The following description is a modification of that by Brunn.[6]

Detailed descriptions of the other stages are reserved for a future publication.

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[5] Fifteenth Ann. Rept. State Ent., Ill., p. 57.

[6] Second Report Cornell Univ. Agr. Exp. Sta., p. 153.

Length 5.5 mm. to 7 mm. General color light greenish drab to slate. With the exception of the first, each segment has eight dull white slightly raised blotches, four on each side of the median line. Each bears one or two slender white hairs. Head half as broad as first segment, light yellowish green to light brown. Mouth parts brown. Along the posterior margin of the head is a row of six large deep black irregular spots. The two end spots are sub-marginal, triangular and slightly larger than the others. There is also a somewhat paler spot at the base of each mandible. A row of four similar spots extends across the first segment midway between the anterior and posterior margins. The spots are larger than those or the head. Thoracic, abdominal, and anal legs well developed. Outer surface of thoracic legs black and smooth. Inner surface same color as ventral surface of body and sparsely furnished with hair.

Treatment.—As the insect works within the leaf, arsenical or other sprays would have little if any effect. The only vulnerable point seems to be in the method of passing the winter. By destroying the fallen leaves, as by plowing them under, the insects within them will be destroyed, and thus the species held in check.

TISCHERIA MALIFOLIELLA Colem.

Order *Lepidoptera*. Family *Tineidæ*.

The mines of this species were very common in the leaves in the apple orchards examined at Albion and Geneva and were received from Brockport. At Albion at least forty per ct. of the leaves were infested.

The mines are in the upper side of the leaf and are somewhat trumpet shaped. The small end is often curved and marked with crescents of white. The dead and dried leaf tissue turns reddish brown in sharp contrast to the green color of the healthy leaf. At Plate XLI, Fig. 1, an external view of a mine enlarged to twice natural size is shown.

The caterpillars feed and pupate in the same mine. Brunn[7] states that this species probably passes the winter within the mine in the larva state. Our observations were similar, except in one case, when on Oct. 29 a larva was found evidently about to pass to the chrysalis stage, as shown much enlarged at Plate XLI, Fig. 4. At Fig. 3 one of the mines cut open exposing the caterpillar is shown, and at Fig. 4 a single caterpillar. Both are much enlarged. But little is known of the life history of this species and the pupa has not been described. In this State we have found it in Ontario, Wayne and Monroe Counties.

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[7] Cornell Univ. Agr. Exp. Sta., 2d Rept., p. 156.

V. INJURY TO PEACHES BY THE TARNISHED PLANT BUG.

On June 15th Mr. W. T. Rudman, of Rochester, N. Y., brought in a number of Elberta peaches having much the appearance of those shown at Plate XLI, Fig. 6. Some of them showed more injury than those shown in the picture, being nearly covered with sap and much withered. On June 17th the orchard from which these peaches were taken was visited. The cause of the injury was easily ascertained, as there were many tarnished plant bugs on the peaches. A number of them were watched through a lens and could be plainly seen forcing their beaks into the fruit. In several cases a single insect made from four to eight thrusts before leaving the fruit. Mr. Rudman stated that he had noticed the bugs on the fruit for the first time about six days previous to this date. They began to leave the fruit late in June and did not return again during the season.

Nature of the injury.—The bugs usually confined their attacks principally to the under side of the fruit, making large numbers of punctures with their sharp beaks. Within a short time after the punctures were made drops of sap would flow and finally the skin begin to wither. The injured peaches when mature were deformed to a greater or less degree, depending upon the extent of the injury to the young fruits.

Location of infested trees.—All of the trees in which the injury was done were close to the west side of a rather dense woods consisting principally of chestnut and white oak, with an undergrowth of sassafras. The trees in the first three rows nearest the woods were most seriously attacked. On the fourth and fifth rows very little injury was done, and only an occasional injured fruit could be found in the remainder of the orchard.

DESCRIPTION OF PLATES.

PLATE XXXIV.—*Forest tent-caterpillar on apple twig: 1, Dorsal; and 2, lateral view of same caterpillar. From life; natural size. (Original.)*

PLATE XXXV.—*Forest tent-caterpillar: 1, A later photograph of the same twig as in Plate XXXIV. The caterpillar has drawn the leaves together and is forming the cocoon within;* 1^1 *and* 1^2 *show the male and the female moths, natural size; and 2, some of the caterpillars on a young plum tree. Their recently cast skins are seen on the right. From life. (Original.)*

PLATE XXXVI.—*Cocoon of forest tent caterpillar: At 1 the leaves have been partially cut away exposing the cocoon, the caterpillar being still at work within the cocoon when this picture was taken; 2 is from a photograph taken three days later, the cocoon being cut open to expose the chrysalis. From life, enlarged. (Original.)*

PLATE XXXVII.—*Fruit bark-beetle: 1, branch from cherry tree showing leaves killed by beetles; 2, one of the buds enlarged showing hole made by a beetle; 3, exudation of sap from wounds made by the beetles; 4, row of eggs in twig, enlarged; 5, single egg, enlarged. (Original.)*

PLATE XXXVIII.—*Exudation of sap from bark peach tree caused by fruit bark-beetle.*

PLATE XXXIX.—*1, Quince mealy-bugs enlarged; 2, egg cocoon, natural size and enlarged; 3, single mealy bug greatly enlarged, with group natural size; 4, Apple leaves distorted by* Ornix prunivorella; *5, one of the mines greatly enlarged showing the interior. From life. (Original.)*

PLATE XL.—*1, Edge of apple leaf being drawn over by larva of* Ornix prunivorella; *2, from a later photograph; 3, the edge of the leaf is drawn completely over and encloses the larva; 4, cocoon within folded leaf; 5, larva. From life, enlarged. (Original.)*

PLATE XLI.—*1, Mine of* Tischeria malifoliella; *2, larva; 3, larva in mine; 4, larva about to pupate; greatly enlarged; 3 and 4 from life; 5, Peaches injured by tarnished plant-bug.*

Plate XXXIV.—Dorsal and Lateral Views of Forest Tent-Caterpillar.

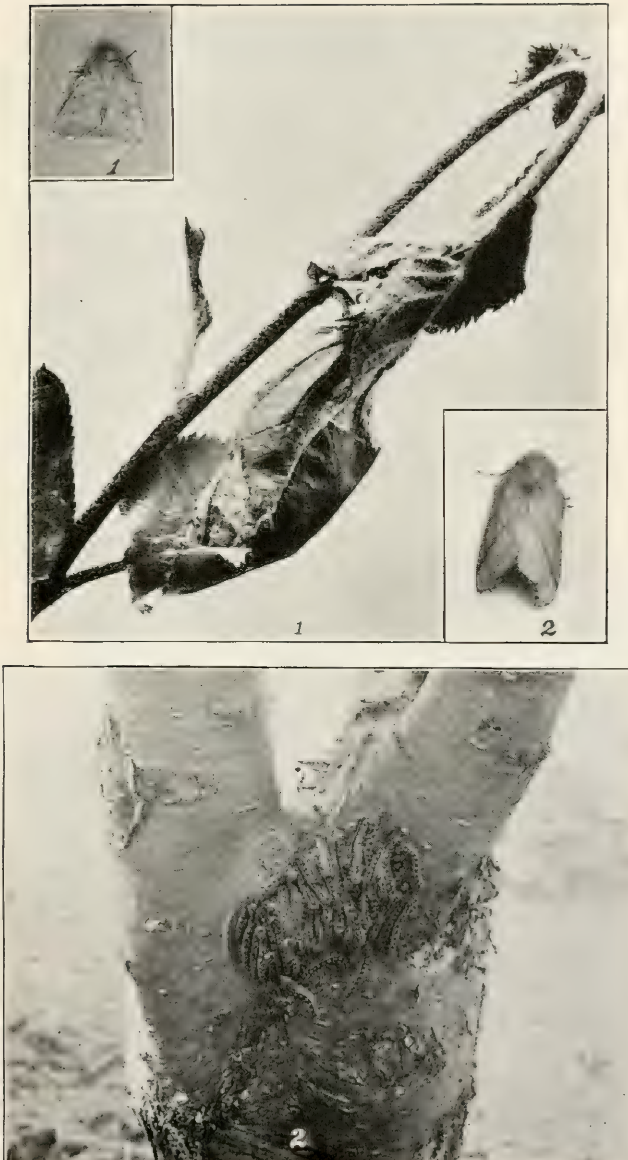

PLATE XXXV.—COCOON, MOTHS AND CLUSTERED LARVAE OF FOREST TENT-CATERPILLAR.

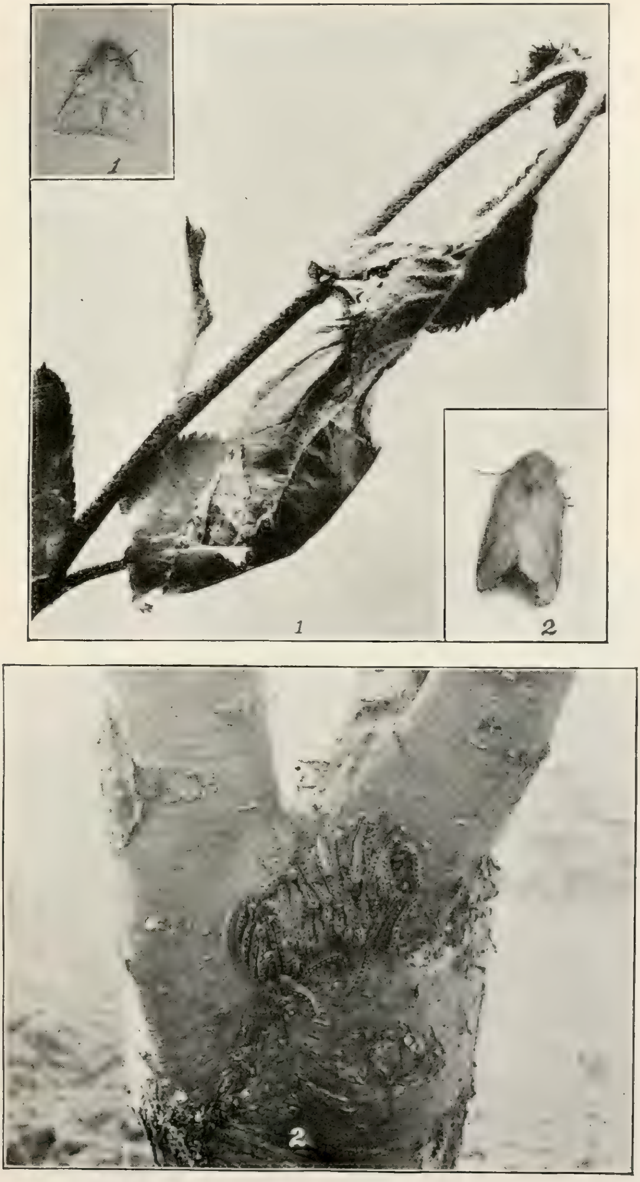

PLATE XXXV.—COCOON, MOTHS AND CLUSTERED LARVAE OF FOREST TENT-CATERPILLAR.

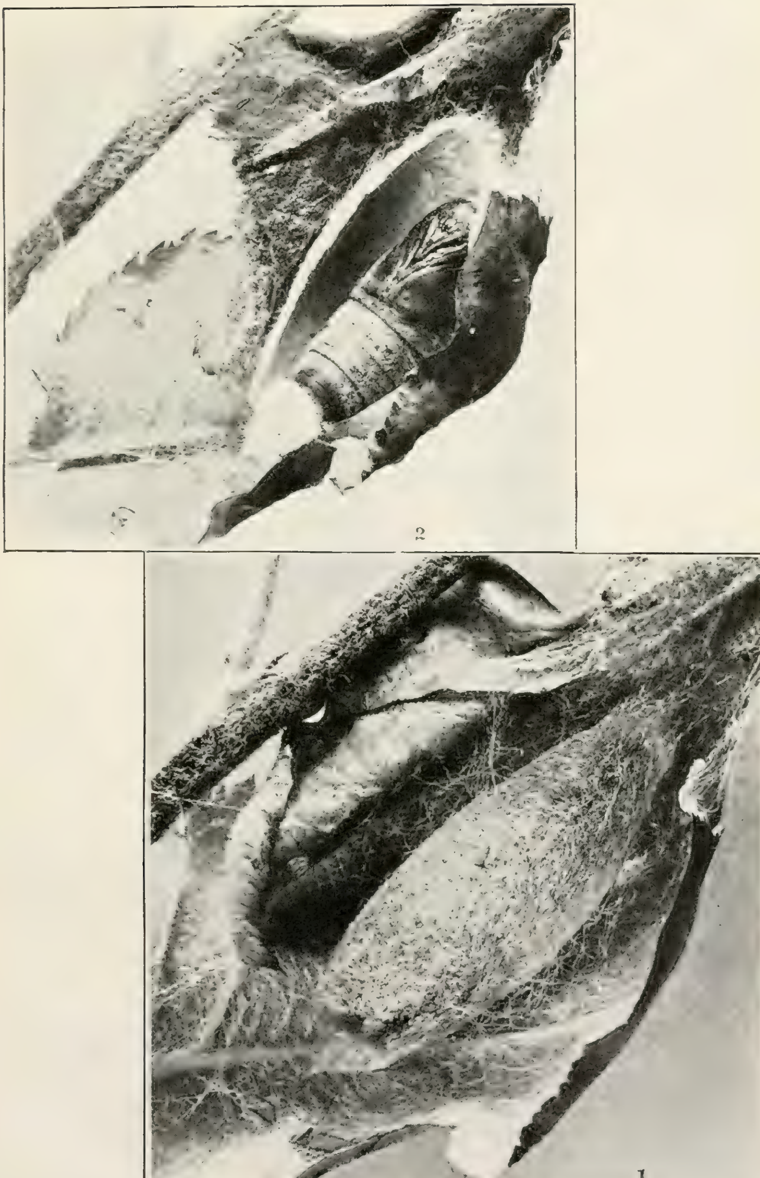

PLATE XXXVI.—ENLARGED COCOON AND CHRYSALIS OF FOREST TENT-CATERPILLAR.

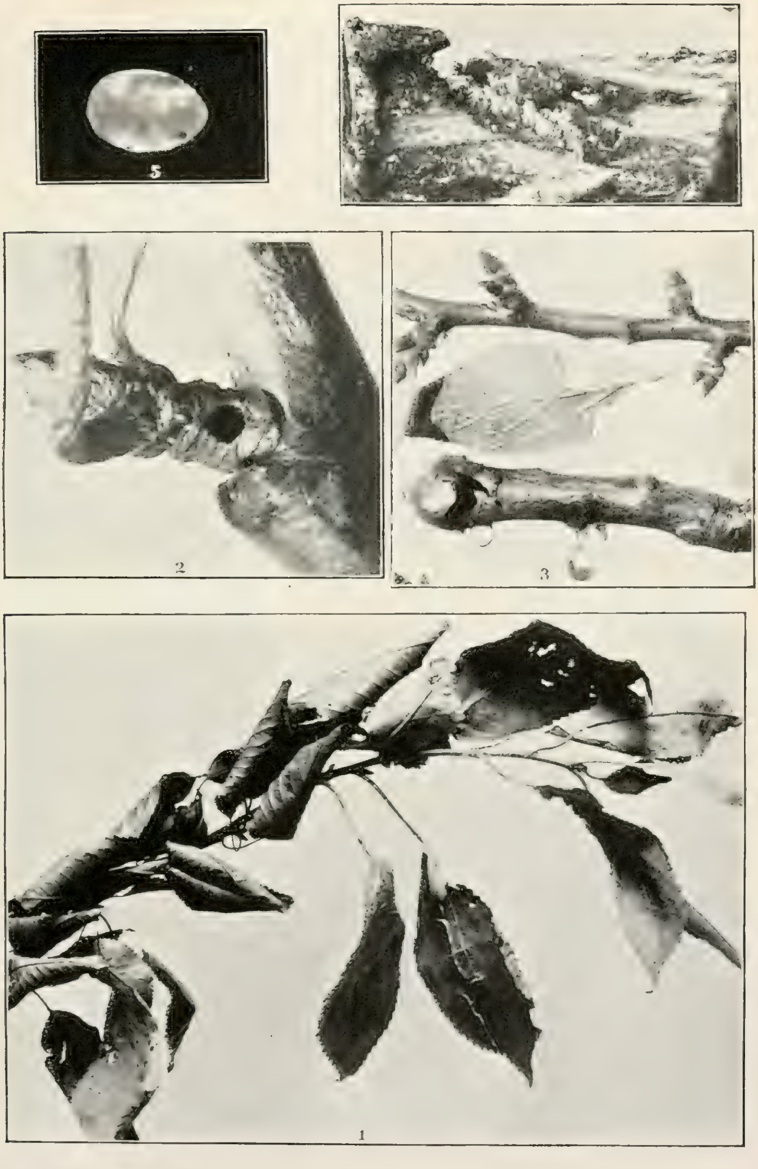

Plate XXXVII.—Injury, Puncture and Sap Exudation Caused by Fruit Bark-Beetle; with Row of Eggs in Twig and Single Enlarged Egg.

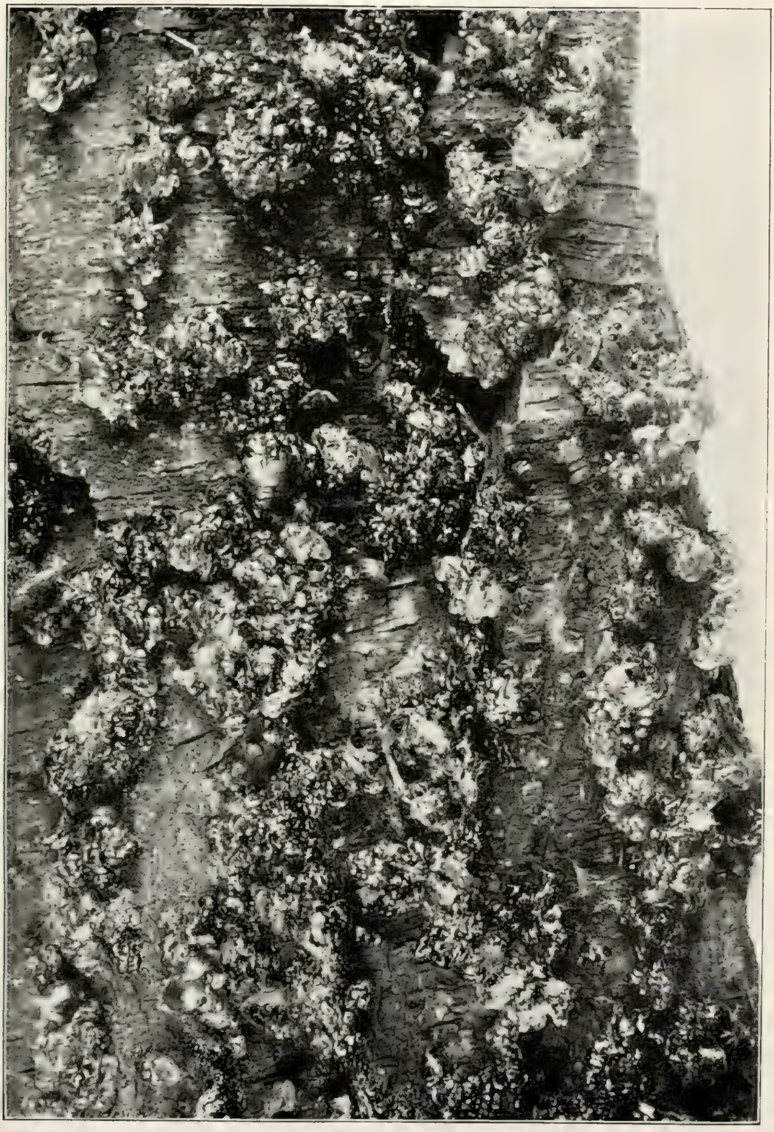

Plate XXXVIII.—Exuded Peach Sap from Punctures of Fruit Bark-Beetle.

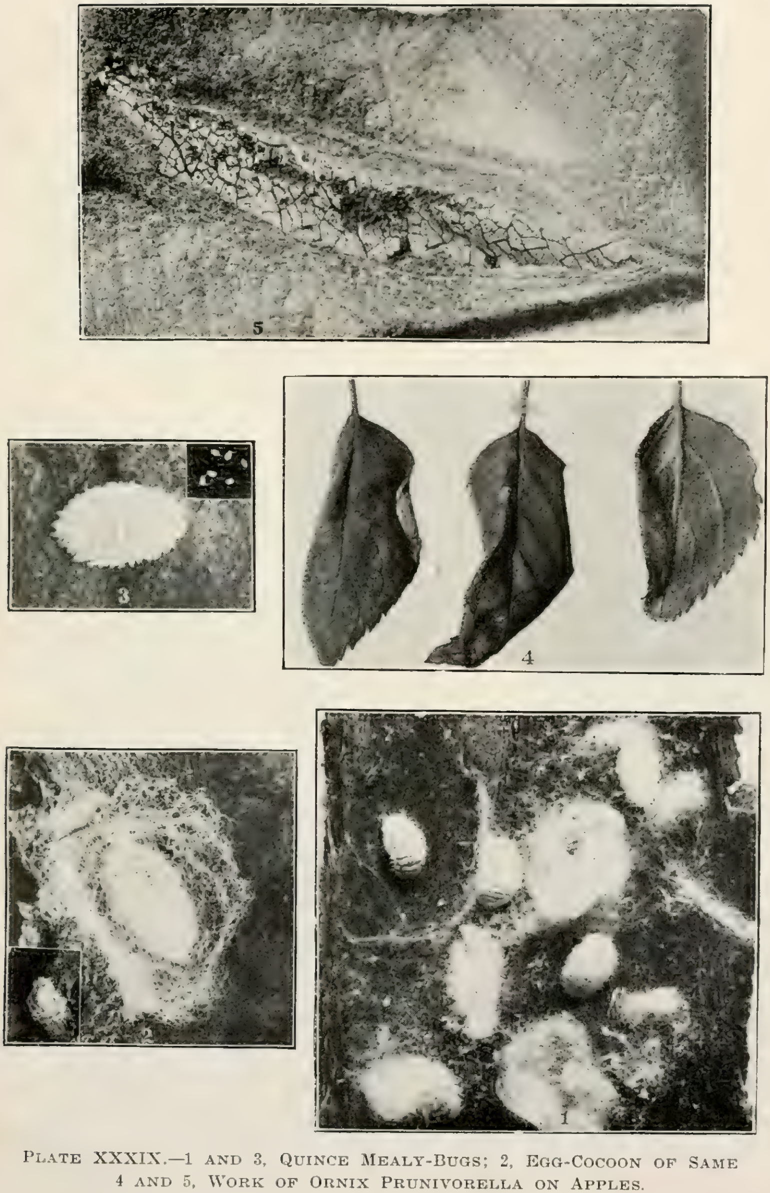

PLATE XXXIX.—1 AND 3, QUINCE MEALY-BUGS; 2, EGG-COCOON OF SAME
4 AND 5, WORK OF ORNIX PRUNIVORELLA ON APPLES.

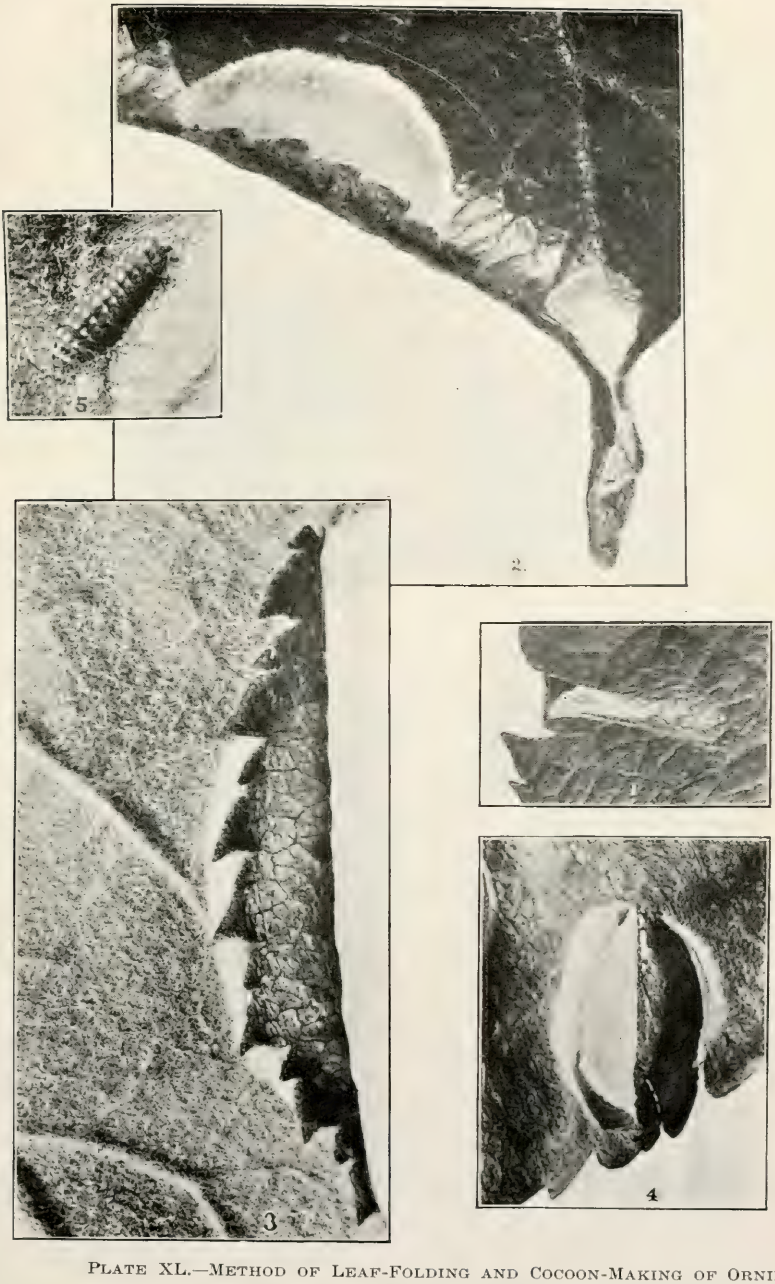

PLATE XL.—METHOD OF LEAF-FOLDING AND COCOON-MAKING OF ORNIX PRUNIVORELLA, WITH LARVA.

PLATE XLI.—1-4, MINE AND LARVA OF TISCHERIA MALIFOLIELLA.
5. PEACHES INJURED BY TARNISHED PLANT BUG.

A FUMIGATOR FOR SMALL ORCHARD TREES.*

V. H. LOWE.

INTRODUCTION.

The fumigator described herein was planned at the Station for use in a series of orchard fumigation experiments with hydrocyanic acid gas. It has been carefully tested with such good results that a brief description in bulletin form seems desirable. This style of fumigator is intended for use with the smaller orchard trees, such as peach, pear, plum and quince. Trees larger than the dimensions of the fumigator can often be trimmed back sufficiently to go under it without injury.

DESCRIPTION OF FUMIGATOR.[1]

CONSTRUCTION.

A picture of the fumigator in position ready for use is shown at Plate XLVI. The dimensions are 10x6x6 feet. The frame consists of well-seasoned pine strips three inches wide and seven-eighths inch thick, braced on three sides by double cross pieces of the same thickness and one and one-fourth inches wide, midway between the top and bottom, and short braces at the angles, as shown at Plate XLII. The base is made of four-inch strips and has but three sides, the fourth being omitted to avoid the necessity of lifting the fumigator over the top of the tree before putting it in place. To add to the rigidity of the base two strips three by seven-eighths inches extend from the rear strip to the

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*Reprint of Bulletin No. 181.

[1]Since writing the bulletin the author has been told, by Prof. W. G. Johnson, that he has designed and used a similar fumigator.

sides, as shown by Plate XLII. On the inside of the front and top a strip projects two inches, against which the adjustable side rests when in position. Plate XLII, *a*. Two light strips extend across the top to support the canvas. On two sides of the frame and outside of the canvas two stout strips are bolted on a convenient distance from the ground to serve as handles used in carrying the fumigator, as in Plate XLIII. The fourth side is made of the same material as the frame, and fits snugly in place against the two-inch flange previously referred to.

The frame is covered with any suitable gas-tight material. Eight-ounce duck was used on the two fumigators tested. It was sewed together in such a way that the three sides were covered with one large sheet. In one case raw oil and white lead were used to make the canvas gas tight, and in the other shellac with one coat of oil and white lead. Any of the substances used in making gas-tight tents will answer the same purpose. As it is desirable to have the canvas dark in color, lamp black was mixed with the oil in both cases. Heavy, unbleached sheeting is cheaper than canvas, weighs less and being thinner and closely woven takes less material to make it gas tight. With ordinary care in handling there is little danger of tearing the covering, especially if it is made of material as strong as eight-ounce duck; but as a precaution a stout wire net may be tacked on the inside of the upper half of the frame, thus preventing the limbs of the trees from touching the canvas.

A strip of canvas one and one-half feet wide is securely tacked to each side of the base of the frame. The strips lap at the corners, so that when the fumigator is in place they lie flat on the ground and can be covered with dirt or sand bags, thus preventing the escape of the gas. The strips can be hooked up out of the way when the fumigator is being carried from one tree to another. Plate XLIII. The movable side of the fumigator can be easily put in place or taken off. Four handles, shown at Plate XLV, are conveniently placed for use. The two-inch flange against which it rests is covered with a good quality of felt about one-fourth of an inch thick, glued on as well as tacked, to

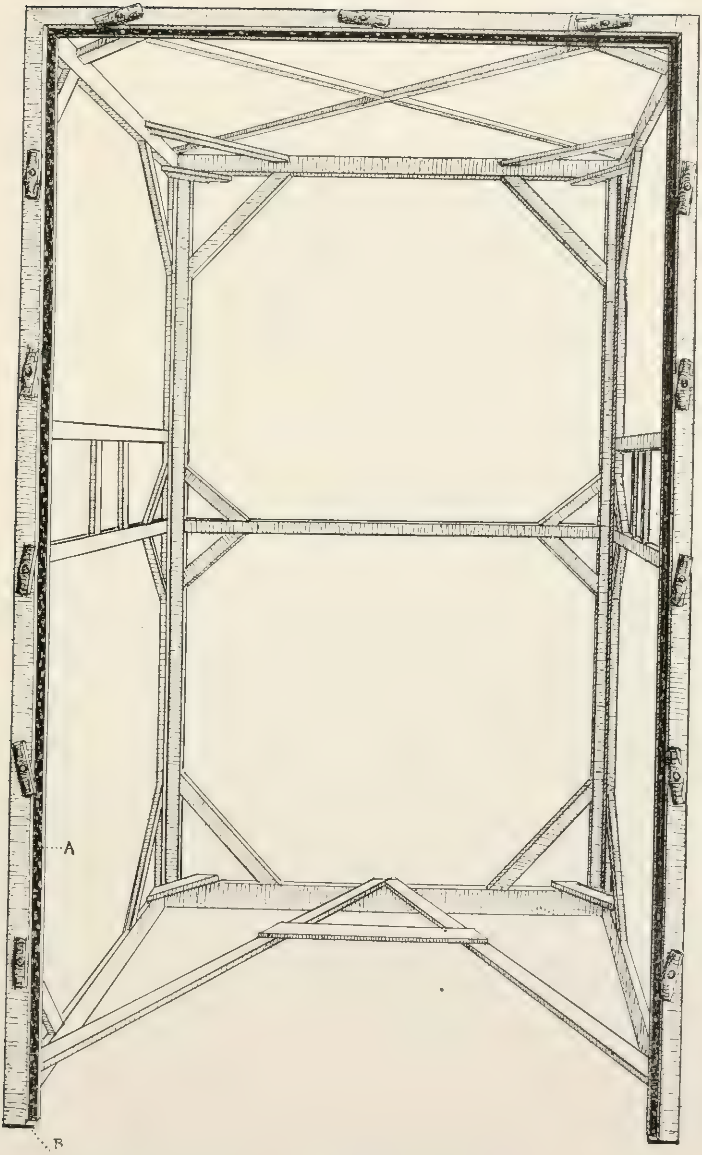

PLATE XLII.—PLAN OF FUMIGATOR FRAME.

PLATE XLIII.—PLACING FUMIGATOR OVER TREE.

PLATE XLIV.—ACID DISH AND CYANIDE BAG IN POSITION.

PLATE XLV.—FASTENING DOOR OF FUMIGATOR.

PLATE XLVI.—FUMIGATOR IN OPERATION; SHOWING DIRT THROWN ABOUT BASE.

prevent leakage of gas. The surface of the frame which rests against the flange is also covered with the same material, fastened on in the same manner, so that when the movable side or door is in place the two surfaces of felt come together. Two flat metal pieces projecting on each side of the base of the frame are for the door to rest upon and prevent it from fitting into place until it is forced tight against the top. Plate XLII, *b*. Thirteen beveled buttons of oak force the door into place and press the felts close together. The buttons are made of wood bolted on and work on strips of tin to prevent tearing the canvas. The buttons are forced into place by a wooden mallet, as shown at Plate XLV. Metal binding handles such as used on cold-storage doors answer the same purpose and are somewhat easier to operate, but cost more.

COST OF CONSTRUCTION.

The cost of a fumigator 10x6x6 feet should not exceed $13, if heavy sheeting is used to cover the frame. A good quality of wire net, enough to line the upper half, will cost from $2.50 to $4 additional. If eight-ounce duck is used the cost will reach about $18.

USE OF FUMIGATOR.

OPERATING.

A fumigator of this model, 10x6x6 feet, is easily carried and operated by two men. A fumigator 12x8x8 feet, probably the largest size of this style that would be practical, would require three men. The removal of one side of the fumigator prevents the necessity of lifting it up over the tree in order to put it in place. It is placed over the tree in the manner shown at Plate XLIII. At Plate XLIV the plan of setting off the charge is shown. The bag of cyanide is placed over the dish of acid either upon one of the cross braces or in the manner shown in the picture. A string tied to the bag extends through a small hole in one of the upright strips of the frame. When all is ready the string is gently pulled from the outside and the bag falls into the acid. The hole is then closed with a tight-fitting wooden plug.

The fumigators used in our experiments were provided with small windows, one on either side, so that the bag could be watched as it fell into the acid and the action of the acid noted.

During some of our experiments the strips of canvas at the base of the fumigator were covered with dirt, as shown at Plate XLVI. This method was finally discarded and bags half full of sand substituted, as they were found to be more easily handled and equally effective in making the base of the fumigator tight. A stout water-proof bag 6 feet long and of small diameter, two-thirds full of sand, will be found convenient for this purpose. Four would be required for each fumigator and could be handled easily.

The time required for moving the fumigator from one tree to another and putting it in place will vary somewhat; but in our experiments in an orchard of standard Bartlett pear trees two men moved the fumigator from one tree to another and set it up in ten minutes without unusual effort.

SOME ADVANTAGES OF THIS STYLE OF FUMIGATOR.

There are at least four advantages over the tent and its modifications which may be claimed for this style of fumigator.

1. Its cubic contents can be accurately computed, thus ensuring correct treatment with the gas.

2. The same amounts of chemicals are used for each charge, thus avoiding the necessity of changing the amount for each tree, and of weighing cyanide in the field, which usually requires an extra man where three or four fumigators are in operation. The slight cost of chemicals that might be saved on trees not large enough to fill the fumigator is immaterial unless the trees are very small. In such cases, if there are many of them, a fumigator of smaller size could be used.

3. Fewer men are required to handle it than would ordinarily be required to handle a tent large enough to cover trees that can be treated with the size of fumigator described.

4. As the fumigator does not rest upon the tree there is little if any danger of serious injury to buds or breaking of small limbs.

SUMMARY.

Although the fumigator was severely tested in two of the more important points in its construction, the danger of leakage and spreading at the base, it proved entirely satisfactory. Heavy charges of sulphur smoke and hydrocyanic acid gas were used to ascertain whether there was any leakage between the felts, but none could be detected. The frame has also remained rigid, there being no indications of spreading at the base or otherwise becoming out of shape.

In constructing the fumigator, a light but rigid frame should be aimed at and much care should be taken to make the adjustable side a fairly tight fit. The small metal flanges at the base of the frame are also of special importance, as they prevent the door from slipping down and thus allowing the gas to escape at the top.

A LITTLE-KNOWN ASPARAGUS PEST.*

Agromyza simplex Loew.[1]

F. A. Sirrine.

SUMMARY.

The asparagus miner is not generally known as an injurious pest to asparagus, its work being first observed in the fall of 1896.

There are two distinct broods of the miner on Long Island.

At present the only known means of controlling the increase of this pest is pulling the old stalks after they have been killed by frost and burning them.

INTRODUCTION.

During the fall of 1896 the author accompanied the Station Botanist on a tour of inspection of the asparagus fields for asparagus rust. While in the fields some plants were pulled to ascertain if the rust occurred on the portion of the stalk below the surface of the ground. Many stalks were found to have the puparia of some fly buried beneath the epidermis especially in the portion of the stalk which was below the surface of the ground. Some of the material was preserved for breeding, but the lack of a suitable place, at that time, for keeping such material so that it would not get too dry, resulted in our failing to breed the adults. During the past year the adult fly was reared from some of the old, infested stalks collected early in May. This pest has no common name. Possibly "asparagus miner" would be appropriate.

* Reprint of Bulletin No. 189.

[1] Kindly verified for the author by Mr. D. W. Coquillet, Washington, D. C.

Fig. 1.

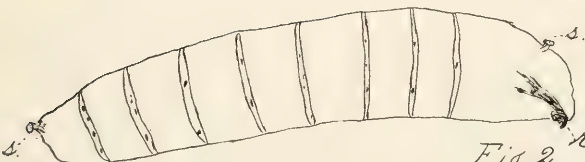

Fig. 2.

Fig. 3.

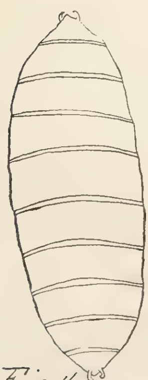

Fig. 4.

Fig. 5.

PLATE XLVII.

THE ASPARAGUS MINER.

HISTORY.

This fly has been known to collectors for a number of years, but as far as can be learned, what it feeds upon has not, hitherto, been ascertained, or its life history worked out. In 1897 Mr. Chittenden[2] of the Division of Entomology, Washington, D. C., reported collecting it on asparagus and suggested that it might feed upon that plant. The only species of fly reported in European literature as infesting the asparagus plant is a species of Ortalis[3] known as the "asparagus-fly," the maggots of which burrow into the stalk of the asparagus and work downward to the root.

DESCRIPTION.

As the adult fly has already been described in works on diptera only a general description is given here.

Adult.—The adult is a small, metallic-black fly, 3 to 4 mm. long (about one-sixth inch) and rather broad as compared with its length; it is usually found resting upon flowers and branchlets of asparagus and especially on plants that have been gnawed or eaten by the asparagus beetle. A modified camera lucida drawing of this fly is shown on Plate XLVII, Fig. 1.

Egg.—The eggs have not been found.

Larva.—The larvæ or maggots are about 5 mm. long, somewhat flattened and of a white or transparent-white color. It is found only beneath the epidermis near base of asparagus plants. Fig. 2, Plate XLVII is a greatly enlarged drawing of the larva, giving a side view. The black rasp-like jaw or proboscis is shown at *r*, the cephalic and caudal spiracles are shown at *s*, *s*.

Puparium.—The puparium, or resting stage, of this miner resembles the "flax-seed" stage of the "Hessian fly." The

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[2] U. S. Dept. Agr., Div. Ent. Bul. 10, n. s.

[3] *Platyparea pœcilloptera* Schrank (*Ortalis fulminans* Mg.) J. Böttner. Praktisches Lehrbuch des Spargel-baus. Frankfurt a. Oder: Trowitzsch u. Sohn, 1897, p. 100. *Trypeta fulminans*, E. H. Meyer in Braunschw. Landw. Ztg., 65 (1897): No. 3, pp. 9–10.

puparia show as small, oblong, dark-brown, raised spots beneath the epidermis near the base of the asparagus stalk and are often mistaken for the rust pustules. If taken from beneath the epidermis during the fall they are generally amber-brown in color and oblong in shape, with two minute horns or projections at each end. After remaining in the stem all winter they are generally very dark brown in color. See Figs. 4 and 5, Plate XLVII.

LIFE HISTORY.

The adult flies issued in confinement May 30. They were taken in the field on asparagus June 8. On June 19, puparia and maggots were found beneath the epidermis of this season's growth. No adult flies were to be found. None of the adult flies were taken again until August 2. After this date occasional specimens of adult flies and of maggots were noticed until the asparagus was killed by frost. During all the fall the puparia were plentiful and apparently many of the maggots which changed into puparia the latter part of August remained in this condition over winter.

HABITS AND METHOD OF WORK.

The adult flies can be found around the flowers, but they were generally found congregated around wounds made by the asparagus beetle, apparently feeding upon the juices exuding from these wounds. The place and method of depositing the eggs were not determined, but frequently the mine made by a maggot started beneath a leaf scale and generally near the surface of the ground, thus indicating that the eggs are sometimes deposited under or near the leaf scales. In some instances mines were found which started nearly a foot above the ground, but generally the majority started at or near the surface of the ground and extended downward below the surface of the ground for distances varying from 3 to 4 inches.

The work of this pest should not be confused with the injury of the European asparagus fly, which mines into the stalk; while the above species simply works beneath the outer bark or epider-

mis and devours all the green portion of the plant between the epidermis and the bast, or wood, fiber. Five or six of the maggots will usually completely girdle a stalk. Their method of mining, with a "flax-seed" or puparium in the mine, is illustrated in Fig. 5, Plate XLVII.

The puparia are always formed within the mines and generally below or near the surface of the ground where the old, dead stalks remain moist.

AMOUNT OF INJURY.

This pest has been watched during the past four years, and no noticeable injury from its work has ever been detected on cutting beds. During 1900 they were apparently more numerous than common and considerable injury from their work was observed on seedling and newly set beds. The injury showed itself by the plants first turning yellow and finally dying much earlier than they naturally should do. Possibly the fact that the structure of the asparagus plant is such that it can withstand girdling much better than more woody plants accounts for the injury not being noticed. Furthermore, the life history of the pest is such that the first brood cannot get much of a foothold on cutting beds, especially where ridging is practiced. Although the injury to cutting beds is not noticed, there is no doubt that the plants are materially weakened, later, by the attacks of this pest.

NATURAL ENEMIES.

At present it is not known what natural enemies this pest has. As yet no parasites have been bred from the puparia. The only enemy noted in the field was another small fly, which was not identified, feeding upon the fly of the asparagus miner.

REMEDIES.

The habits of this asparagus pest are such that there is little chance of applying insecticides and none have been tested. Cultural and preventive measures can be and should be applied. As the eggs for the first brood are deposited early in June undoubtedly much could be done toward keeping this pest under control

by not allowing any small shoots to grow on cutting beds during the cutting season. Where new beds are being put out yearly, pulling and allowing the old stalks to dry and burning them will aid in keeping the pest under control. The stalks can be pulled and burned any time after they are dead, but when possible it should be done late in the fall. Where left until spring the stalks rot to such an extent that the bark slips off, in pulling, and the puparia are left in the ground.

CONCLUSIONS.

Growers of asparagus are not generally aware of the work and injury of this pest, as it usually works in the asparagus stem below the surface of the ground.

Its work was first noticed on asparagus in the fall of 1896.

It is not known where or how the eggs are deposited.

There are at least two distinct broods of this pest on Long Island.

It is suggested that this pest be called "asparagus miner."

The injury, such as it is, is done by the maggot.

It is still a question whether this pest does enough injury to cutting beds to warrant growers going to any extra expense to get rid of it, but this does not necessarily prove that it may not become a troublesome pest, as it is already known to injure seedling beds.

At present the only means that can be given to control it is pulling of the old asparagus stalks as soon as they are killed by frost, and burning them.

SAN JOSÉ SCALE INVESTIGATIONS. I.*

THE DEVELOPMENT OF THE FEMALE.

V. H. LOWE AND P. J. PARROTT.

SUMMARY.

The females were found to pass through three well-defined periods during development: The period of activity which follows very soon after birth and during which they move about freely; the period of growth, at the beginning of which they insert their mouth parts into the tissue and begin to suck the sap and to form the scale; and the period of reproduction, at the close of which they die.

The young scale insects under observation remained active for an average period of 27.7 hours at temperatures above 70° F. Temperatures below 60° F. caused them to settle very quickly.

During the period of activity the larvæ can cling to insects of various species and may be carried by them to new localities to which these larger insects happen to go from the infested trees.

The duration of the period of growth was found to average 49.5 days. Four distinct stages in scale formation were apparent: the cottony stage, the tufted stage, the black stage and the mature stage.

The temperature experiments showed the larvæ to be unable to develop at an average temperature of 35° F., but able to develop to the black stage at a temperature of 45° F. Adult females were able to survive this temperature three months and to produce young soon after being removed to a temperature of 70° F. At 58° F. some of the larvæ developed to the adult stage.

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*Reprint of Bulletin No. 193.

INTRODUCTION.

The past three years have demonstrated that the San José scale will thrive in some of the best nursery and fruit-growing sections of the State. This fact, together with its well-known destructive powers, makes it an important factor in the business of New York nurserymen and fruit-growers. There is, therefore, much demand for information concerning this important species. With a view to meeting the requirements of the situation, extensive series of investigations have been planned bearing upon its development, distribution and control. The present bulletin deals principally with the development of females of the late broods.

The investigations aim to present an exhaustive study of the subject and much pains is being taken to work out each phase in detail, as it is believed that only by such thorough work can the true nature of this as well as other species be fully understood. Such investigations should form the basis for practical experiments having in view the control of such pests.

As the work was not actively begun until last fall the results thus far obtained are necessarily somewhat fragmentary. Further investigations along the same and similar lines are being carried on.

PERIODS OF DEVELOPMENT.

The *Coccidæ* present a marked difference in the development of the male and female. The stages preliminary to the mature form are well marked in the former, while in the latter they are not. After the female larva settles down there is a uniform development with little change except in size. There are, however, at least three well defined periods through which both forms pass, as follows: The period of activity, the period of growth and the period of reproduction.[1] The sexes were found to be practically indistinguishable in the early stages, there being no definite rela-

[1] With the male the period of reproduction is also a period of activity as it flies readily.

tion between sex and size of larvæ, but later developments of the specimens under observation showed a small percentage of males. Hence the facts recorded for the female larvæ apply also to the males.

PERIOD OF ACTIVITY.

Duration.—This period includes the time from birth until the larva settles down. Its duration is influenced greatly by temperature, as will be seen by comparing the following table, which gives the record of larvæ kept in the insectary and laboratory at temperatures of from 70° to 76° F., with the records of larvæ kept in rooms at lower temperatures, on page 311.

TABLE I.—LENGTH OF ACTIVE PERIOD OF SAN JOSÉ SCALE LARVÆ IN INSECTARY AND LABORATORY.

Number of larvæ in each lot.	Date of birth.	Date transferred to apple.	Settled.	Remarks.
20	Sept. 1	Sept. 2	28 hrs.	Insectary.
150	" 3	" 4	17 to 28 "	One larva of this lot was active for 48 hrs.
20	" 9	" 10	18 "	
3	" 12	" 13	18 "	
10	Oct. 5	Oct. 6	12½ "	
4	" 24	Not transferred	2 in 36 " 2 in 36 to 48 "	
280	Sept. 8	Sept. 9	28 "	Laboratory.
120	" 9	" 10	28 "	
90	" 10	" 11	28 "	
50	" 16	" 17	28 "	

The total number of larvæ recorded in this table is 747. None of them settled in less than 12½ hours, while a number remained active for from 36 to 48 hours, making the average number 27.7 hours, or a little over one day.

The larvæ probably remain inactive for a short time after birth. To secure data on this point the scales were removed on Sept. 25 from three adult females and on Oct. 8, from three more. Up to Dec. 13 the six gave birth to 263 larvæ, 20 of which were born enclosed in the amniotic sack. Until the sack was ruptured they appeared as minute, oval, light-yellow bodies. Most of the imprisoned larvæ did not succeed in freeing themselves, but those that successfully ruptured the sack escaped in

from 1 to 48 hours. Those that were born free remained motionless near the anal plate of the mother for from one-half hour to four hours.

Distance the larvæ migrate.—During the active period the larvæ move about very freely. The distance they can migrate unaided naturally varies with the character of the surface over which they travel and with the temperature. It is not probable that they travel very far over loose earth, but to determine this point more observations are needed. During our investigations the nearest approach to data on this phase of the subject was in the case of an infested apple placed on the ground about four inches from the base of a small apple tree growing in the shade in the insectary. The soil about the tree was well packed and moderately moist. The apple remained for three weeks during which time the larvæ were numerous and active, but none were found on the tree. It is possible that the larvæ did not attempt to leave the fruit, but a large number of cases were observed in the laboratory where they wandered freely from infested apples kept under similar conditions, thus indicating that they have a definite tendency to migrate from the fruit.

A more definite illustration of the power of the larvæ to migrate was furnished by a simple experiment with a single larva. December 27 a young larva measuring 0.2 mm. in length was placed on a smooth piece of paper at 10.05 a. m. The temperature of the room averaged about 74° F. The larva traveled almost continuously, with occasional stops, for six hours, during which time it had covered 10½ feet, or about 16,000 times its own length.

The larvæ appear to have a tendency to seek sheltered places on the bark and fruit before settling down. This is especially noticeable in cases of moderate infestation. On fruit, the blossom end or stem end is usually sought by a majority of the larvæ, the former often being preferred. It is possible that the position of the fruit may have some influence, as, after the fruit turns down, the blossom end is less often, if at all, in the direct rays of sun-

light. With this in mind 20 larvæ were placed on each of 10 smooth-skinned apples. Immediately after being infested half of the apples were placed on shelves in the laboratory, stem end down and half blossom end down. In two days all had settled and in every case about three-fourths settled on the under side where there was the least light, the remaining one-fourth being scattered.

It is also very noticeable that on infested apple and pear fruits a majority of the young scales will be found grouped about the adults. An examination of a large number of infested fruits, including apple, pear, quince, plum and peach, showed about eight-tenths of the young scales gathered about the adults that had made slight depressions in the fruit, probably as a result of sucking the juice and the consequent withering of the tissue, while but comparatively few were found about those that had not made a depression. A number of typical groups are shown much enlarged at Plate XLIX, Figs. 1, 2, 3 and 4. At Fig. 3 a male scale is shown with a number of young about it. At Plate LI, Fig. 1, a large group is shown, also much magnified.

Mortality of the larvæ.—The active larvæ are very small and comparatively delicate, and probably under ordinary conditions a large percentage do not succeed in passing the active period. To ascertain the mortality among larvæ kept as near normal conditions as possible, seven adult females were kept under observation for several weeks. They were enclosed in cells like those described on page 316. The temperature of the room in which they were kept varied from 70° to 75° F. during the day and dropped to about 60° at night. The scales were removed from three of them. The mortality among the larvæ from these females is shown in the following table:

TABLE II.—MORTALITY OF SAN JOSÉ SCALE LARVÆ DURING ACTIVE PERIOD.

No.	Reproductive period.	Number young produced.	Number lived to settle down.	Number died.	Percentage of mortality.	Remarks.
1	Sept. 25 to Nov. 14	59	52	7	11	Scale not removed.
2	" "	12	2	10	83	" "
3	" "	26	20	6	23	" "
4	" "	87	67	20	23	" "
5	" "	14	4	10	70	Scale removed.
6	" "	61	34	27	44	" "
7	" "	12	9	3	25	" "
	Totals	271	188	83	Average 39.8	

In two of the records the percentage of mortality is very high, while in the remainder, with the exception of No. 6, not more than 25 per ct. perished. Although all of the females and young were kept under the same conditions, no reason for the much higher percentage of mortality in some cases than in others could be ascertained. As shown by the table the average mortality was almost 40 per ct., leaving about 60 per ct. that lived to settle down. The comparatively small number produced by each female is noticeable, but it is not exceptional to our experience with a large number of other females of the fall broods kept under observation. It is not improbable that females of the late broods give birth to fewer young than those of earlier broods.

PERIOD OF GROWTH.

Duration.—The period of growth lasts approximately from the time the larva settles down until the beginning of the reproductive period. In the field there is much variation in the duration of this period. In the laboratory and insectary there was also much variation, especially in the case of 19 of the larvæ under observation. Fifteen of these were transferred to smooth-skinned apples and kept in the insectary and four were placed on the smooth bark of a young apple tree also in the insectary. The results are shown in the following table:

TABLE III.—LENGTH OF PERIOD OF GROWTH OF SAN JOSÉ SCALE LARVÆ.

Larva No.	Date settled down.	Date began to reproduce.	No. days.	Remarks.
1	Sept. 6	Oct. 24.	48	On apples in laboratory.
2	" 6	" 27.	51	" "
3	" 6	None to Dec. 31.		" hibernating.
4	" 6	" "		" in adult stage.
5	" 6	" "		" "
6	" 6	" "		" "
7	" 6	Oct. 28.	52	" "
8	" 6	None to Dec. 31.		" "
9	" 6	" "		" "
10	" 6	Oct. 25.	49	" "
11	" 6	None to Dec. 31.		" "
12	" 6	" "		" "
13	" 6	Oct. 29.	53	" "
14	" 7	On Nov. 11 had 25 larvæ		" "
15	" 6	None to Dec. 31.		" "
16, 17, 18	Aug. 29	Oct. 7 had together 101 larvæ.		Nos. 16, 17, 18 kept in one cage and were overlooked until Oct. 7. On apple tree in insectary.
19	" 29	Oct. 12.	44	On apple tree in "
	Average		49.5	days.

The table shows that but ten or a little more than half of these females produced larvæ. With these, however, the period from date of settling down until young were produced was fairly uniform varying from 44 to 53 days with an average of 49.5 days. At Plate XLVIII, Fig. 1, some larvæ are shown that have just settled down and are about to begin forming scales.

It is during this period also that the discoloration of the tissue begins. The irregular blotches produced by the young scales individually and collectively on fruit and leaves are shown at Plate XLIX, Fig. 6 and Plate LI, Fig. 2.

Formation of the scale.—In the formation of the scale by the female there were usually apparent four well defined stages based upon its outward appearance as follows: (1) The white or fluffy stage, (2) the tufted stage, (3) the black stage and (4) the fully formed stage.

The white or fluffy stage.—The first indication of the formation of the scale is the secretion of white cottony filaments that cover the body at first sparingly but finally become quite dense until the insect has the appearance of a white oval mass of fluffy cot-

tony fibres loosely woven together. This first covering is very delicate and can be easily removed. The scales under observation showed a variation in the time of the first appearance of the white secretion of from 6 to 24 hours, but in all cases when the young scales were kept in a warm room or the insectary this stage was reached within 24 hours after the larvæ had settled down. The secretion of the filaments is normally quite rapid, as the larvæ were usually completely covered with them within six or eight hours after they first appeared. Plate XLVIII, Fig. 2.

The tufted stage.—At the beginning of this stage a denser layer of waxy threads is seen projecting from beneath the loose threads over the margin of the body. This is the true scale. As the insect increases in size this portion of the scale is enlarged. The loose white filaments form a central tuft which in many cases becomes three or four times the diameter of the scale, as shown at Plate XLVIII, Fig. 3. The true scale soon begins to turn dark passing through several shades of dirty gray until it becomes nearly black. The tuft grows smaller slowly, probably weathering away, until it finally disappears, leaving a crater-like depression at the apex of the scale. Plate XLVIII, Fig. 4 and Plate XLIX, Fig. 4; the small scale on the left.

The black stage.—This stage is characterized by the dull black color of the scale and usually at first by the crater-like depression at or near its apex, which is later filled by the nipple. It begins when the white tuft has disappeared. During this stage the scale becomes thicker and its texture is more compact than at any previous time. In the latitude of New York State the insect hibernates in this stage, hence its duration varies greatly with the time of year. Plate XLVIII, Fig. 5.

The mature stage.—As the insect grows the scale is enlarged by the secretion of the white waxy fibres which may often be seen projecting from beneath the scale as shown at Plate XLVIII, Fig. 6. This white mass soon turns dark, usually a dull dirty gray, and forms a large part of the scale. The mature scale is characterized by its comparatively large size, the prominent, usually central, nipple and the light-yellowish areas caused by

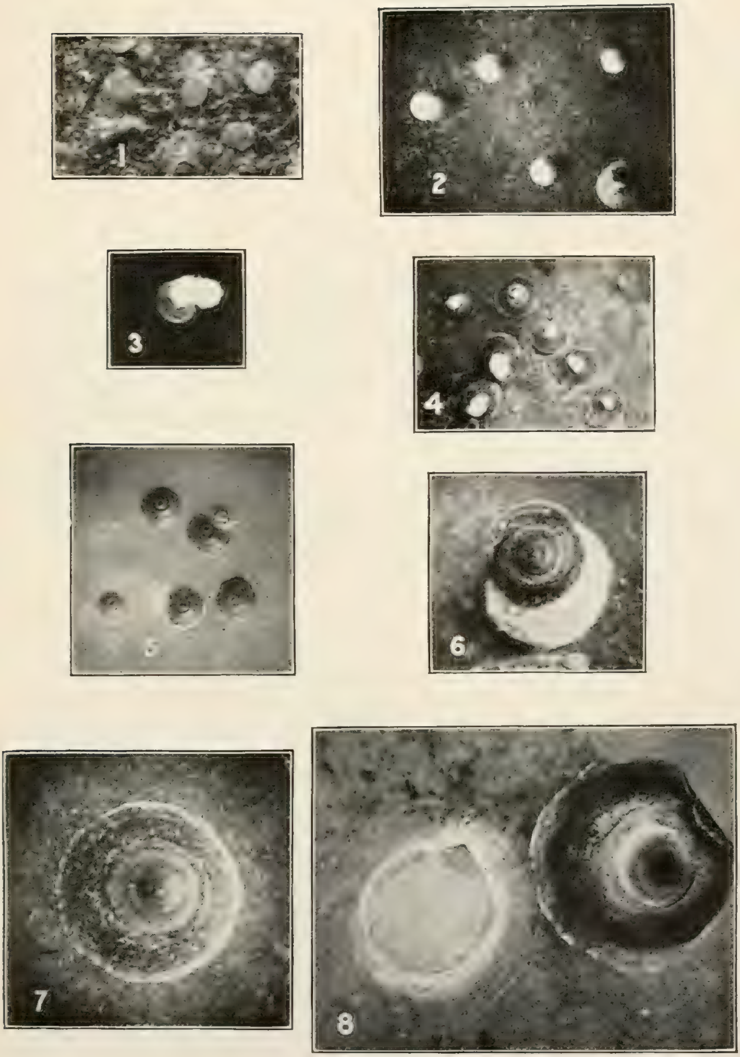

PLATE XLVIII.—1-6, SUCCESSIVE STAGES OF SCALE FORMATION; 7, FEMALE SCALE; 8, FEMALE WITH SCALE TURNED BACK. (Original.)

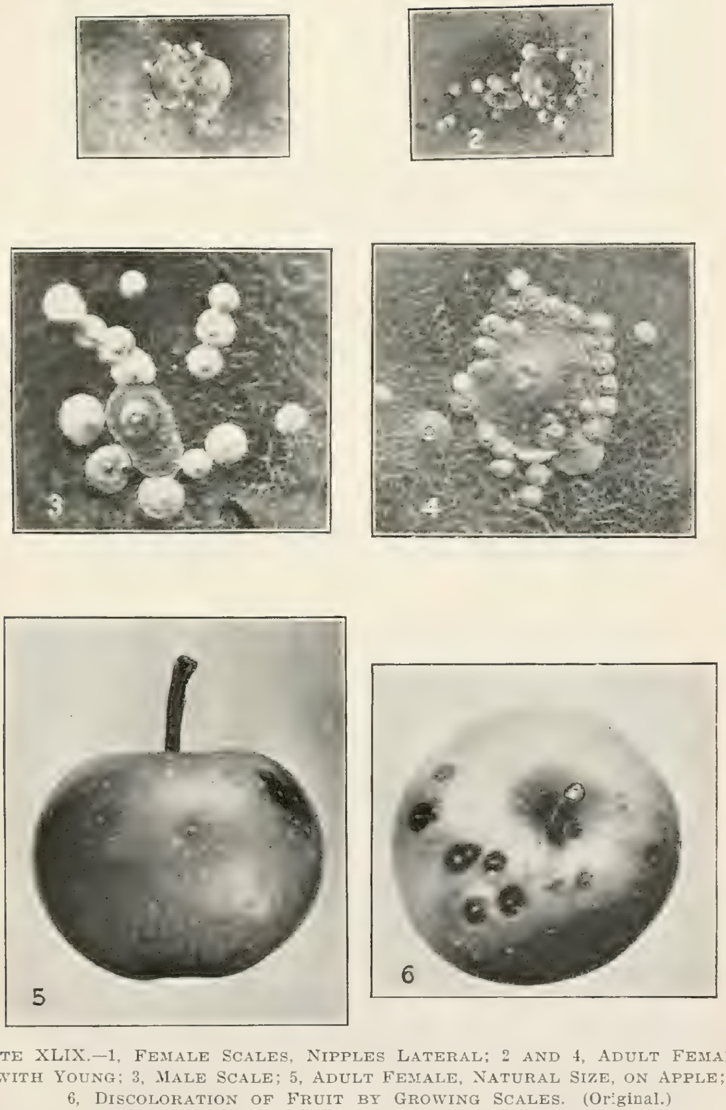

PLATE XLIX.—1, FEMALE SCALES, NIPPLES LATERAL; 2 AND 4, ADULT FEMALES WITH YOUNG; 3, MALE SCALE; 5, ADULT FEMALE, NATURAL SIZE, ON APPLE; 6, DISCOLORATION OF FRUIT BY GROWING SCALES. (Original.)

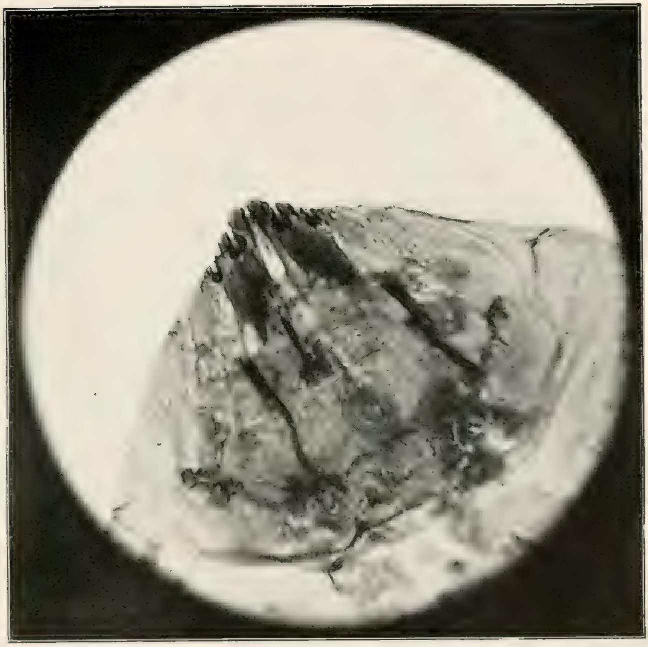

FIG. 1.

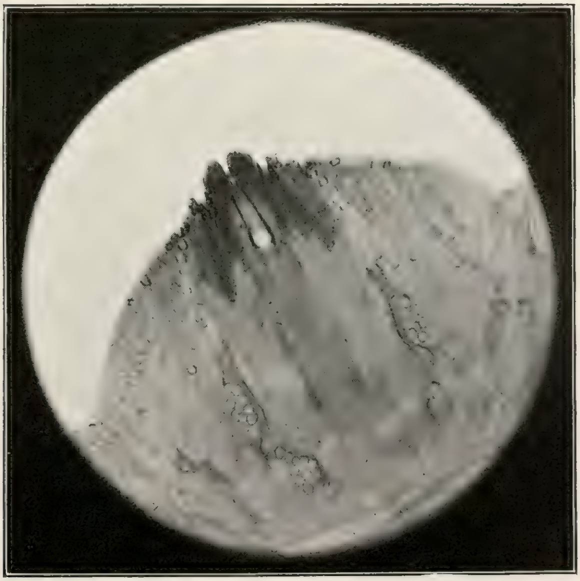

FIG. 2.

PLATE L.—1, ANAL PLATE OF ASPIDIOTUS PERNICIOSUS; 2, ANAL PLATE OF ASPIDIOTUS OESTREAEFORMIS.
From photomicrographs. (Original.)

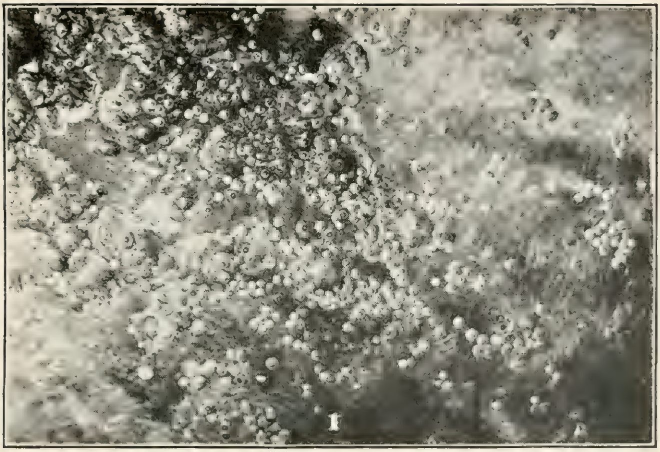

PLATE LI.—1, PORTION OF A GROUP OF SCALES ON AN APPLE; 2, INFESTED PEAR LEAVES SHOWING DISCOLORATIONS CAUSED BY GROWING SCALES.

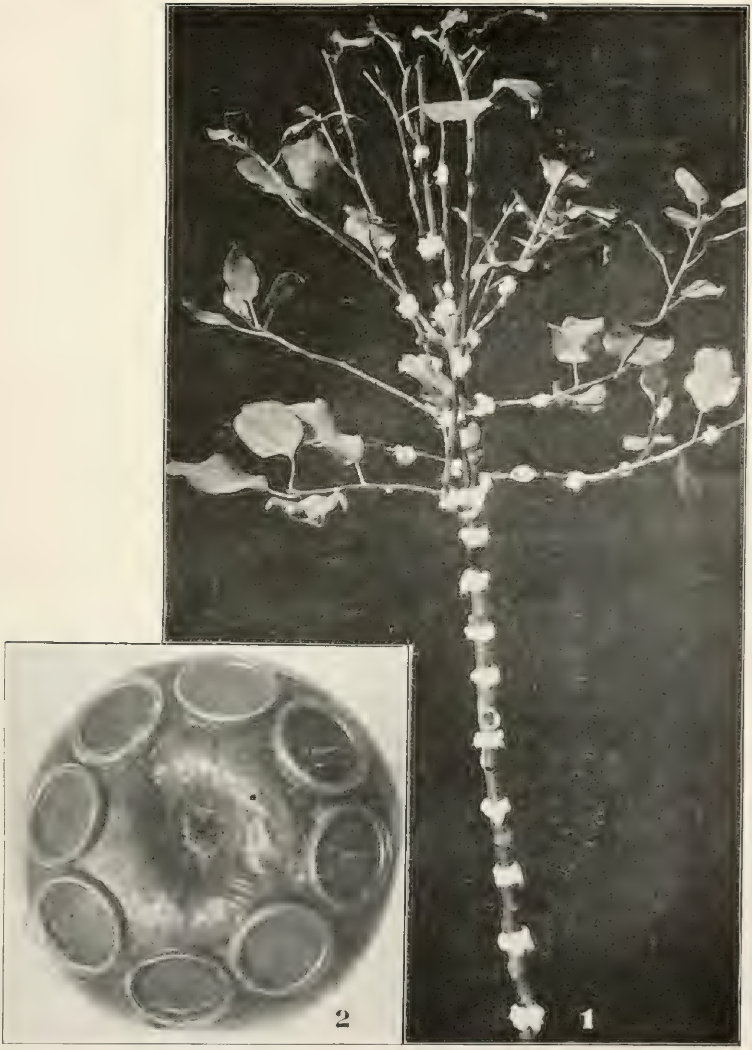

PLATE LII.—1, COTTON BANDS AND CELLS ON YOUNG APPLE TREE USED TO CONFINE ACTIVE LARVAE; 2, CELLS ON APPLE IN WHICH ACTIVE LARVAE ARE CONFINED AND GROWING SCALES ISOLATED.

the molted skins showing through the scale. In many cases the nipple is near the margin as shown at Plate XLIX, Fig. 1. The two large scales in this picture are adult females. The first molt causes the whole central area of the scale to appear a lighter shade than the remainder. The white cottony mass which is forced beyond the edges of the scale turns dark, forming a dark ring. The second molt forms a lighter area, which, as it shows only toward the edge, the scale now being much thinner at the edges than toward the apex, forms a lighter ring. Thus there are two more or less distinct broad light bands with a narrow dark band between. Plate XLVIII, Fig. 7. At Plate XLVIII, Fig. 8, a mature scale is shown turned back exposing the living insect. The dark area forming the posterior extremity of the insect's body is the anal plate. It is by means of the microscopic characters of this plate that the species may be definitely determined. Plate L, Fig. 1 is from a photomicrograph of the anal plate of the San José scale, and Fig. 2 of *Aspidiotus œstreœformis*, a species common in this State that is sometimes mistaken for it.

While the above description of scale formation is fairly typical, there is much variation. In this connection the following notes giving the details of the formation of the scales of a number of individuals kept under the same conditions may be of interest. All of the larvæ were placed on smooth-skinned apples and kept in the laboratory or insectary.

No. 1.—Ten larvæ born September 4. By September 8 they were completely covered by the white cottony secretion. On this date the cottony mass was removed, but by September 10 it was replaced by another covering of waxy filaments which were more closely matted together than the former. The scales were white like the first and on this date showed a faint indication of a central nipple but no ring about the nipple. By the following day a slight ring-like depression had formed about the nipple. Until September 19 there was no apparent change but on that date the scales appeared to be turning darker in color. By September 21 they had begun to turn very dark, nearly black on the outer

margin, and on September 28 were black over their entire area except the white nipple at the center. At this point further change in the scales ceased and the insects are now dormant.

No. 2.—One larva born September 12. By September 14 the white cottony substance had formed a prominent tuft near the center with the yellow body of the insect showing around the margin. The following day the entire body was covered. September 17 a small white fluffy tuft had formed a little to one side of the center with the remaining portion of the scale white but more dense and firm. September 19 the margin was turning dark with the nipple still white. The gradual change to darker shades continued and on October 4 the scale was much darker with a white tuft at center surrounded by a narrow ring of yellow, caused by the first molt, and a second ring of yellow at the margin caused by the second molt. By October 8 the main portion of the scale was dark brown and by October 12 it was black, the white nipple still persisting. There was no further development of this scale as it gradually became dormant.

No. 3.—Under this number are included ninety larvæ born September 3 and transferred to apples, six on each apple, the following day. They were kept in the insectary and the formation of the scale was so uniform that the lot may be discussed as a whole. An examination, September 6, showed them to be completely covered by a grayish-white scale with a central nipple just apparent. By September 8 the nipple had turned to light gray and was surrounded by a dark brown indented ring followed by a broad base of dark gray. By September 14 the whole scale, except a narrow brown margin, was black. September 17 most of the scales showed a narrow band of white on the margins caused by the pressing out of the white cottony substance secreted by the insect. Plate XLVIII, Fig. 6. September 21 the scales were black or very dark gray but still showed the white extension. October 8 the first molt of one of the scales had taken place. Nearly simultaneous with the molt the discoloration of the skin of the fruit appeared. October 12 some of the specimens showed second molt and the males were now distinguishable by

the elongation of one side of the scale. By October 16 one male showed first and second molt-areas, light yellow in color. A narrow dark-brown ring separated the two areas. The lateral extension was light gray. October 30 one of the female scales was mature. The first and second molts showed the broad light yellow bands with the narrow dark band between and the margin dark brown. The entire scale was covered with a white pollinose substance. The remaining scales had all reached the black stage and were dormant.

No. 4.—This group included eight larvæ born September 18 and kept on apples in the laboratory. They were not examined until September 29. On this date they could be divided into two lots based on the outward appearance of the scale. Lot 1 was well covered with a tuft of white cottony substance. Lot 2 had molted. All of this lot had a white nipple at the center surrounded by a narrow slightly depressed band, deep brown in color. On the outer margin of this depression was an elevated ring of the same color and covered with a white pollinose substance. From this elevated ring the scales sloped down to a nearly flat surface which formed the boundary of the oval figure and was composed largely of the molted skin. This area was light brown in color in nearly all cases, with a narrow black extension on the margin. After this date there was no further development of either lot.

PERIOD OF REPRODUCTION.

This period probably begins very soon after full development. Owing to the fact that many of the scales under observation have yet passed only to the hibernating stage we are able to present the records of but seven females which are given in the following table. It will be noticed that the average number of days is 30.2 while the highest number of young produced in a single day was 8 and the average for the entire number was but 1.07.

TABLE IV.—NUMBER OF LARVÆ PRODUCED BY SEVEN FEMALES WITH DAILY RECORD OF EACH.[3]

	1	2	3	4	5	6	7	Remarks.
Oct.								
14				*23*				
26				4	5			
27	*18*	1		8	4			
28	2	0	4	0	5			
29	7	0	2	0	3			
30	0	2	1	2	8			
31	1	0	3	6	0			
Nov.								
1	1	0	4	4	1			
2	1	1	2	1	1			
3	2	2	1	0	0			
4	2	0	0	2	2			
5	3	0	0	1	2			
6	5	0	0	0	4			
7	0	0	0	0	0			Temperature dropped to 58° F., which evidently checked development.
8	5	1	0	1	2			
9	5	3	0	0	0			
10	1	1	2	0	0			
11	1	0	0	0	2		*52*	
12	0	0	0	0	5		3	
13	0	0	2	0	0		0	
14	1	1	2	1	7		2	
15	6	0	0	0	1		1	
16	1	0	0	0	0		1	

	1	2	3	4	5	6	7	Remarks.
Nov.								
17	1	1	1	3	1		0	
19	1	0	1	0	3		2	
20	3	0	6	0	1		1	
21	0	0	0	0	3	*10*	0	
22	0	0	0	0	0	0	5	
23	2	0	0	0	1	0	2	
26	1	0	0	0	7	0	0	
27	1	0	0	0	5	1	2	
28	0	0	1	0	0	0	0	
29	3	0	2	0	0	1	0	
30	0	0	0	0	6	0	0	
Dec.								
1	1	0	0	0	2	0	1	
3	0	0	0	0	2	0	2	
4	0	0	0	0	0	0	2	
5	0	0	0	0	1	0	2	
7	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	
8	0	0	0	0	2	0	0	
10	0	0	0	0	2	0	2	
11	0	0	0	0	0	0	0	
12	0	0	0	0	0	0	0	
13	1	1	0	0	0	0	0	
14	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	

	1	2	3	4	5	6	7	
No. of days	42	43	30	23	41	7	26	Av. 30.2 da.
No. of larvæ	58	14	34	33	88	2	29	
Average number per day.	$1\frac{8}{21}$	$\frac{14}{43}$	$1\frac{2}{15}$	$1\frac{10}{23}$	$2\frac{6}{41}$	$\frac{2}{7}$	$1\frac{3}{26}$	
General average					1.07			
Total number of larvæ for each female	76	14	34	56	88	12	81	

MOLTING: HOW ACCOMPLISHED.

Laboratory observations upon individuals from which the scale had been removed showed that in molting the skin splits along the anterior margin and for a short distance along the lateral margins. It is then forced off the posterior end of the body by the motions of the segments.

The following observations upon the molting periods are from 320 males and females kept in the laboratory. For convenience they were divided into lots as follows:

Lot 1 consisted of 160 larvæ born September 4. September 17 one larva showed first molt. About half the remainder did not

[3]Numbers in Italics represent number of larvæ born when observations were commenced.

show first molt until October 1, while nearly all the other half showed the second molt on the same date. The majority of the scales were dark gray in color at the time of first molt.

Lot 2 consisted of six larvæ born September 5. They showed first molt September 19.

Lot 3 consisted of one larva born September 25. October 6 showed first molt. The scale at time of first molt was white with white central nipple.

Lot 4 consisted of 150 larvæ born September 3. October 8 two individuals showed first molt. In both cases the scales were black. October 12 the same specimens showed second molt. On this date, also, all of the males showed second molt and the lateral projection of the scale was becoming apparent. Up to the time of writing, December 31, the remaining larvæ have not molted, but are dormant in the black stage.

Lot 5 consisted of one larva born October 5, first molt October 30. At the time of molting the scale was light gray in color with crater-like depression at the center. To December 31 there is no trace of a second molt. The insect is now dormant.

Lot 6 consisted of ten larvæ born September 11. They were on a young apple tree in the insectary. October 12 no appearance of first molt. October 26 one female had passed second molt. The remainder are dormant (December 31) without showing first molt.

Lot 7 consisted of one larva born September 25. By October 14 it had passed the second molt. At this time the white central tuft still remained. By October 25 it had disappeared. The first and second molt-areas were dirty yellow and the remainder of the scale gray.

Lot 8 consisted of five larvæ born August 25 and placed on young apple trees in the insectary. October 5 all showed second molt and were characterized by a central light-yellowish area and black band toward margin. October 7 a number of larvæ were born from these females.

Lot 9 consisted of one larva born August 31. There was no

indication of first molt until October 5; after which the insect became dormant.

Summarizing the above: The first molts of 91 larvæ were recorded and the period from birth to molting found to vary from 11 to 35 days, the average number being 20.7. The second molts of 87 larvæ were observed and the number of days from birth found to vary from 14 to 45 days or an average of 29¼ days, while the period from the first to the second molt in the case of five larvæ was four days. In all cases there was no constant relationship between the stage of development of the scale and the molts.

Rate of growth of the scale.—The table on following page shows the rate of growth of the scales of three larvæ during the first half of the period of growth. None of the scales lived to mature. As the growth of the insect and its scale is probably at nearly the same rate the measurements are of interest as indicating the rate of growth of the insect as well as its scale.

EFFECTS OF TEMPERATURE ON DEVELOPMENT.

The effects of temperature on the development of the scales is well understood in a general way. It is a matter of common observation that the larvæ are usually more numerous and active during warm than cool days. Also that the half-grown insects withstand severe cold, otherwise they could not endure our winters. But it is yet not fully understood whether young scales attached to fruit or nursery stock kept in cold storage will continue to develop, are merely checked, or cannot survive. Also whether mature scales under the same conditions will survive and produce young when brought into higher temperatures. The following data was obtained from larvæ placed on apples and kept in rooms having temperatures as follows: Checks kept in insectary and office temperature 72–75° F. developed normally. Room 1 had an average temperature 35° F., Room 2, average

TABLE V.—RATE OF GROWTH OF SCALE.

Date.	Rate of growth. Larva No. 1.	Larva No. 2.	Larva No. 3.	Remarks.
Sept. 27..	.254 mm.			
" 28..	.293 "			
" 30..	.400 "			
Oct. 1..	.418 "			
" 2..	.418 "			
" 3..	.420 "		.325 mm.	
" 5..	.420 "		.327 "	
" 6..	.436 "		.330 "	
" 7..	.455 "		.345 "	
" 8..		.200 mm.		
" 9..	.637 "	.273 "	.364 "	
" 11..	.655 "	.290 "	.364 "	
" 12..	.655 "	.309 "	.400 "	
" 13..	.655 "	.364 "	.418 "	
" 14..	.655 "	.368 "	.418 "	
" 15..	.655 "	.368 "	.418 "	
" 16..	.655 "	.368 "	.418 "	
" 17..	.655 "	.372 "	.418 "	
" 18..	.655 "		.436 "	
" 19..	.655 "	.372 "	.473 "	
" 20..	.658 "	.374 "	.473 "	No. 2. No change after Oct. 20.
" 21..	.658 "		.473 "	
" 22..	.658 "		.473 "	
" 23..	.673 "		.473 "	
" 24..	.673 "		.473 "	
" 25..	.673 "		.473 "	
" 24..	.673 "		.473 "	
" 25..	.673 "		.473 "	
" 26..	.691 "		.473 "	
" 27..	.691 "		.473 "	
" 29..	.728 "			
" 30..	.728 "		.473 "	
" 31..	.728 "			
Nov. 1..	.746 "		.473 "	
" 2..	.746 "		.473 "	No. 1. Nearly mature on Nov. 2 but no further growth.
" 8..			.491 "	No. 3. No change after Nov. 8.
Averages.	.6 "	.33 "	.43 "	

temperature 45° F., Room 3, average temperature 58° F. The young scales were divided into lots and placed upon sound apples which were then placed in the cold storage rooms with the following results:

Room 1.—Average temperature 35° F. Lot 1 consisted of twenty larvæ, born September 9, and transferred to apples September 10. They were immediately placed in Room 1. In half an hour all had settled down. The following morning each was

covered with the white fluffy scale. September 14 no change was apparent except with two larvæ, one of which had pushed the scale nearly off from the body[1] while the scale of the other had begun to turn light brown. September 22 the scales of two larvæ were somewhat more dense than the others but otherwise there was no apparent change. From this time on there were no further signs of development and by December 20 they were dead.

Lot 2. This lot consisted of 13 larvæ born October 5 and transferred, the following morning, to an apple which was at once placed in Room 1. They settled down almost immediately. October 8 they were dormant and naked with the exception of two which showed faint traces of cottony threads. One was sparsely covered with them. Examinations were made every other day but no further development was apparent. November 17 they were carefully examined and found to be dead.

Summary.—The effect of an average temperature of 35°F. upon the young larvæ is here indicated and definitely shown so far as the larvæ under observation were concerned. They settled down almost immediately and attempted at once to cover themselves with a scale. More than half succeeded in doing this, but all perished before reaching the normal hibernating stage.

Room 2.—Average temperature 45°F. Lot 1 consisting of 84 larvæ born September 4 and transferred to apples the following morning.

September 6. All had settled, a few of the white fibres showing in every case but one and this larva was naked.

September 8. Nearly all showed the white central tuft.

From this time on there was no further development until October 24, when six infested apples (36 larvæ) were transferred to the insectary where the average temperature was 75°F. By October 27 a slight indication of development was apparent. October 30 the white fibres of the new addition to the scales were

[1] This has been observed in the laboratory. It is done by a movement of the posterior segments.

apparent on most of the specimens. The scales continued to enlarge slowly in this way until November 9, when the insects apparently ceased their activities and still remain dormant. Nearly all of them reached the normal hibernating stage.

The effect of this temperature upon the adult females was shown by a number that were kept three months in this room and then removed to the laboratory. Within two days after the change some of them were producing young.

Summary.—These results are interesting in showing that the young larvæ, although apparently unable to develop to the hibernating stage in a temperature of 45° F. were still able to resist this temperature for six weeks and when transferred to a room of higher temperature to continue development to the normal hibernating stage; also that the adult females may withstand it and produce young soon after being removed to a higher temperature.

Room 3.—Average temperature 58°F. Lot 1 consisted of ten larvæ borne September 1 and transferred to one apple September 2 which was immediately placed in the cool room. The scales were not again observed until September 29 when they could be easily divided into three groups according to the external appearance of the scale, as follows: Group 1, four larvæ, scales light-brown; Group 2, five larvæ, scales dark gray approaching black, with small white central tuft. Group 3, one larva, side black. October 3, Group 1, light-brown, quite convex, with black addition to margin. Group 2 and 3, no change. October 5, Group 1 has passed first molt. The scales show characteristic light central area with narrow black band at margin of the scale. Group 2, no change. Group 3 has passed first molt. October 8, Group 1, very dark brown, nearly black. Group 2, no change. Group 3, black with dark brown nipple. From this time until October 30, Group 1 showed steady growth, passing the second molt and becoming full size about this date. Groups 2 and 3 showed no further change.

Summary.—In this case the temperature of 58° F. was not sufficient to materially check growth until the normal hibernat-

ing stage was reached and one insect succeeded in reaching full development.

General summary.—These experiments are of practical interest in indicating the temperature required in a cellar for cold storage of trees or fruit to prevent the development of young larvæ or to kill the adult females, which if able to survive the cold would probably produce young, as was the case with the adults referred to on page 313 very soon after being brought into warmer temperatures. This is of especial interest in connection with cold storage of fruit. It will be noticed that at a temperature of 45° F. development was merely checked and continued when the scales were brought into higher temperature, while at 35 F. none of the young scales survived.

MEANS OF LOCAL DISTRIBUTION.

It is during the active stage that the insect is distributed locally. There are three principal agencies which aid in local distribution. First, the activity of the larva which enables it to migrate from one place to another; second, the wind which may carry infested leaves and twigs about; and third, insects, birds and similar agencies. The ability of the larva to migrate over smooth surfaces has been previously referred to.

Wind.—To ascertain the probability of the larvæ being carried on foliage by the wind, 200 pear leaves were picked and carefully examined October 1, and although the larvæ were numerous on the trees none could be found on the leaves. Ten leaves were then placed on the ground and a larva on each. In one hour all had gone except two which remained three hours. October 4, when the larvæ were numerous and active on the infested pear trees, 1680 green leaves on the trees were carefully examined and but 54 larvæ were found. A larva was then placed on a pear leaf which was released from a point about 10 feet from the ground. It was carried by a light breeze about 16 feet and when examined the larva had disappeared, evidently having been blown off by the wind. This was repeated six times, the leaves

being carried about the same distance each time. In every instance but one the larva was blown off, and when the leaf to which the larva had successfully clung was again released from the same place the larva did not succeed in clinging to it.

Insects.—At various times from August 26 to October 11 insects that were found on infested trees were caught and examined to see if larvæ were clinging to them. The following is a list:

Grasshoppers. On August 26 one grasshopper was found with four larvæ clinging to it; and on August 29, another with one.

Aphis lion, *Chysopa*. On August 29 two aphis lions, with one larva caught in the hairs on the upper surface of posterior wing of each were found.

Flies, *Sarcophagidæ*. One individual was found on the same date with a larva clinging to one of its legs.

Beetles. A specimen of *Euphoria inda* was found September 1 with seven larvæ clinging to it.

At various times also twelve wasps, representing four species, 30 honey bees, 24 ants and two dragon flies were examined, all of which were taken from trees upon which the young larvæ were very numerous and crawling about actively, but no larvæ were found. In the case of the Hymenoptera it is not improbable that their cleanly habits account for the lack of San José scale larvæ.

CONTROLLING THE INSECTS FOR THE PURPOSE OF STUDY.

One of the difficulties in the way of accurate and extensive observation upon the development of this species has been the difficulty of keeping the active forms within sufficiently narrow limits. To obviate this difficulty, two simple methods were resorted to. First, the use of bands of cotton wool tied about the trunks of small nursery trees or the limbs of larger trees. These bands were placed from one to two inches apart and prevented the escape of larvæ placed on the bark between them. Plate LII, Fig. 1. Second, cells made by cementing glass or metal rings to the bark or fruit with melted paraffin. Half-inch

brass curtain rings proved very satisfactory. Thin circular cover glasses, the same as used in microscopical work, were placed over the rings and held in place by paraffin. Enough paraffin was always used to entirely cover the ring. To admit air small holes were made with the point of a fine needle, through the paraffin, just under the cover glass. Plate LII, Fig. 2.

In our studies sound apples were found very convenient. A single female could be isolated and her offspring easily counted, or a single larva could be kept within narrow limits for close observation.

SAN JOSÉ SCALE INVESTIGATIONS. II.*

V. H. LOWE.

SUMMARY.

In a series of winter spraying experiments with refined (150° fire test) kerosene oil, peach trees were killed with one application of a 20 per ct. mixture of oil with water, and plums seriously injured with a 40 per ct. mixture. Pears and apples were not injured except by the pure oil, and then only slightly. The 20 per ct. mixture of kerosene had no apparent effect on the scales, but the 40 per ct. proved effectual in every case.

Summer applications of 100° and 150° fire test oil showed the former to be dangerous, burning the leaves at a percentage too low to kill the scale, while the latter did not injure the foliage except when applied undiluted.

I. SPRAYING EXPERIMENTS WITH KEROSENE OIL.

The experiments herein recorded were begun two years ago, the original intention being to duplicate them the following year. At that time kerosene oil was used more extensively in combating the San José scale than now. Although crude petroleum is taking its place in many localities it is still used extensively in this State. Where but few trees are to be treated it is often more convenient to use it than crude petroleum, as it is more easily obtained, and in most localities costs less in small quantities.

The number of trees and bushes treated, 382, is not a large one for a series of experiments of this kind, but is sufficient to give

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reliable results. The treating of a large number of trees was purposely avoided in order to give an opportunity of making the treatment thorough and accurate.

OBJECTS OF THE EXPERIMENTS.

The principal objects of these experiments were: To determine the effects of winter applications of kerosene oil (1) on healthy nursery trees and (2) on healthy bearing trees; (3) to determine the percentage of oil required to kill the scale during the winter; and (4) to determine the effects of summer applications upon healthy bearing trees.

CONDITIONS.

Unless otherwise stated only 150° fire test oil was used. In all cases the oil was applied in the form of a spray, the machine being frequently tested to ascertain whether the right proportions of oil and water were being maintained. Much care was also taken to make the applications even, each tree being wet to the same degree.

EXPERIMENTS TO DETERMINE THE EFFECTS OF WINTER APPLICATIONS OF KEROSENE OIL ON HEALTHY NURSERY TREES.

These experiments were divided into two series, the first receiving one application and the second two applications.[1]

Series I.—Sprayed November 22; temperature 49°, high wind, cloudy. Weather during the week following alternately cloudy and bright, with average temperature of 27°.

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[1]Unless otherwise stated, the trees in Series I and II have received one and two applications of oil, respectively.

TABLE I.—NURSERY TREES SPRAYED WITH KEROSENE DURING WINTER: SERIES I.

Trees. Kind.	No.	Age.	Percentage oil.	Results.	Checks.[1]
APPLE:		Years.			
Baldwin	13	2	20	No injury; following season's growth normal.	Good growth.
"	15	2	40	Same.	Same.
"	18	2	100	Same.	Same.
PEAR:					
Bartlett	11	2	20	No injury; following season's growth normal.	Growth good.
"	15	3 and 4	40	Same.	Same.
"	7	3 and 4	100	Very slight injury to tips of branches.	Same.
PEACH:	12	1	20	Within three days all showed injury, May 31 all dead.	No winter killing. Good growth following season.
"	8	1	40	Same.	Same.
"	18	1	100	Same.	Same.
PLUM:					
Bradshaw	9	2	20	No injury; following season's growth normal.	Good growth.
"	6	2	40	Evidence of injury appeared within three days. May 31 five dead, one badly injured lived.	Same.
"	6	2	100	Injury apparent day following application. May 31 five dead; one, slightly injured, fair growth following season.	Same.
QUINCE:	6	3	100	No injury; following season's growth normal.	Same.

Series II.—Sprayed Nov. 22 (see Series I) and March 27. Temperature on latter date 32°. Weather during the week following windy; average temperature 30°.

[1]Checks same number as in first test under each variety.

TABLE II.—NURSERY TREES SPRAYED WITH KEROSENE DURING WINTER: SERIES II.

Trees. Kind.	No.	Age. Years.	Percentage oil.	Results.	Checks.[1]
APPLE:					
Baldwin	9	2	20	No injury. Growth normal following season.	Growth excellent.
"	12	2	40	Same.	Same.
"	17	2	100	Tips of branches slightly injured after second application. Buds apparently uninjured. Growth following season good.	Same.
PEAR:					
Bartlett	8	3 and 4	20	No injury. Growth during following season excellent.	Growth excellent.
"	10	3 and 4	40	Same.	Same.
"	6	3 and 4	100	Slight injury to buds. Growth following season good.	Same.
PEACH:	19	1	20	May 31, all dead to the ground.	Very slight evidence of winter killing. Growth following season excellent.
"	11	1	40	Same.	Same.
"	8	1	100	Same.	Same.
PLUM:					
Bradshaw	13	2	20	No injury; growth normal.	Growth excellent.
"	8	2	40	May 31. Upper third of trees dead.	Evidence of slight winter injury.
"	6	2	100	May 31, five dead nearly to the ground; others much injured.	Same.

Summary.—Five different kinds of fruit trees were used in these experiments, including 46 apple, 33 pear, 38 peach, 21 plum and 6 quince trees, making a total of 144. This is a sufficient number to make a fair test. Summing up the results it will be observed that peach and plum trees, especially the former, were very sensitive, the peaches being killed with a 20 per ct. mixture and the plums in most cases seriously injured with a 40 per ct. mixture. Neither pears nor apples were injured with one application of a 40 per ct. mixture, and the pears only very slightly with two applications, while the apples were uninjured. One hundred per ct., one application, did not injure apples, and injured pears only slightly; two applications hurt both apples and pears slightly.

[1]Checks equal or greater in number than in single test under variety.

SPRAYING EXPERIMENTS TO DETERMINE THE EFFECTS OF WINTER APPLICATIONS OF KEROSENE OIL UPON HEALTHY BEARING TREES.

Series I.—Nearly all of these trees were in excellent condition and were bearing well. The checks were of the same grade. They were sprayed November 22.

TABLE III.—BEARING TREES SPRAYED WITH KEROSENE DURING WINTER: SERIES I.

Trees. Kind.	No.	Age. *Years.*	Percentage oil.	Results.	Checks.[1]
PEAR:					
Dwarf Kieffer,	2	8	20	No injury. Fruit equal to check trees.	Fruit, average yield.
Standard Bartlett,	2	8	20	Same.	Same.
Standard Bartlett,	2	8	40	Same.	Same.
Dwarf Kieffer,	4	12	100	Bark somewhat discolored by oil especially on lower part of larger limbs and upper half of trunk. On May 31 fruit buds were not well set, but foliage good. Growth poor during following season and less than one-fourth crop of fruit.	Same.
Standard Bartlett,	2	8	100	On May 31 the fruit buds were well set, and foliage good. Growth during following season was good, with average yield of fruit.	Same.
PLUM:					
Gueii,	6	8	20	No injury.	Growth good. Fruit above average yield.
Gueii,	3	8	40	No injury.	Same.
Japan,	1	8	100	May 31. Much of the bark discolored; more than ¾ of the fruit buds killed. Tree nearly dead by following fall and was dug out.	Same.
Reine Claude,	1	10	100	May 31. Seriously injured. Nearly dead by following fall and was dug out.[2] But little injury to upper third.	Same.

[1] Two check trees for each test.
[2] Soon after this tree was sprayed it was found to be seriously affected by disease which probably aided materially in causing its early death.

TABLE III.—*Continued.*

Trees. Kind.	No.	Age. Yrs.	Percentage oil.	Results.	Checks.[1]
European,	1	14	100	May 31. Fruit buds well set toward tips of upper limbs. Very little foliage except on upper third. Nearly dead by following fall.	Growth good. Fruit above average yield.
European,	2	8	100	But little injury to upper half. Lower half seriously injured; no foliage and all fruit buds killed. Nearly dead by following fall.	
CURRANT:	2	([3])	100	Within a few days showed injury and died during following spring.	

[1] Two check trees for each test.
[3] Bushes in full bearing.

Series II.—The trees of this series, as those of Series I, were selected as being in good condition. The applications were made November 22 and March 27.

TABLE IV.—BEARING TREES SPRAYED WITH KEROSENE DURING WINTER: SERIES II.

Trees. Kind.	No.	Age. Yrs.	Percentage oil.	Results.	Checks.
CRAB APPLE:					
Hyslop,	1	([1])	20	No injury. Fruit average crop.	
PEAR:					
Kieffer,	2	10	20	No injury. Fruit average crop.	Two trees same age and variety. Fruit usual crop.
Dwarf Kieffer,	1	10	100	About 80 per ct. of fruit buds killed. Foliage good.	Two trees same age and variety. Fruit usual crop.
PLUM:					
Bradshaw,	1	10	20	No injury. Fruit average crop.	
Bradshaw,	1 1	8 10	100 40	More than 80 per ct. of fruit buds killed. Very little foliage. Tree nearly dead by following fall.	

[1] Full bearing.

Summary.—Three different kinds of fruit trees and one variety of currants were used in these experiments, including 15 pears, 17 plums, 1 crabapple and 2 currants, making a total of 35. In all cases there was no injury to pears except where pure oil was used in both Series I and II. Plums were not injured by one application at 40 per ct.; but seriously injured by two applications, and also by one application of 100 per ct.

SPRAYING EXPERIMENTS TO DETERMINE THE PERCENTAGE OF KEROSENE OIL REQUIRED TO KILL THE SAN JOSÉ SCALE WHILE HIBERNATING.

Series I.—The trees were sprayed November 21. Weather cloudy and windy, temperature 42°. During the following week the weather varied from cloudy to clear with an average temperature of 28°.

TABLE V.—PERCENTAGE OF KEROSENE REQUIRED TO KILL HIBERNATING SAN JOSÉ SCALE: SERIES I.

Trees. Kind.	No.	Age. Yrs.	Percentage oil.	Degree of infestation.	Results.	Checks.
PEAR:	3	14	20	Badly infested; incrusted on some parts.	Scales apparently not affected by the oil, May 31 and later.	Scales but little affected by winter. Larvae abundant during following season.
Bartlett,	41	10	20	Majority of trees badly infested, others moderately.	No effect upon the scales.	Same.
Bartlett,	4	10	40	All badly infested; incrusted in places.	May 31. Scales dead; three trees not injured; one tree slight yellowing of leaves.	Same.
Bartlett,	1	10	100	Well infested.	May 31. Scales dead. No injury to tree except bark on lower limbs and upper part of trunk slightly injured, but not seriously.	Same.

TABLE V—*Continued.*

Trees. Kind.	No.	Age. *Yrs.*	Per-cent-age oil.	Degree of infestation.	Results.	Checks.
PEACH:	4	Old	20	Nearly dead with scale. Incrusted on trunk and nearly all limbs.	May 31. Trees dead, and as a result, scales dead also.	Scales but little affected by winter. Larvae abundant during following season.
PLUM: Lombard,	1	8	40	Badly infested.	Scales dead. No apparent injury to tree.	Same.
SWEET CHERRY:	1	12	40	Incrusted on trunk and lower limbs.	May 31. Scales dead. Tree uninjured.	Same.

Series II.—The trees were sprayed November 21 and March 17. Weather bright on latter date, temperature 20. Weather during following week bright. Average temperature 29.

TABLE VI.—PERCENTAGE OF KEROSENE REQUIRED TO KILL HIBERNATING SAN JOSÉ SCALE: SERIES II.

Trees. Kind.	No.	Age. *Yrs.*	Per-cent-age oil.	Degree of infestation.	Results.	Checks.
PLUM: Reine Claude	1	8	40	Badly infested. Incrusted on lower limbs and trunk.	June 29. Scales dead.	Scales not much affected by winter. Larvæ abundant.
Reine Claude	[1]1	8	20 / 15	Badly infested.	June 29. Scales not affected.	Scales not affected by winter. Larvæ abundant.
SWEET CHERRY:	1	[2]	100	Moderately infested.	June 29. Scales dead. Tree somewhat injured.	

Summary.—These experiments included 58 pear, plum, peach and sweet cherry trees. All of them were sufficiently infested

[1]Sprayed with 20 per ct. in late November; with 15 per ct. in early December.
[2]Bearing.

to give definite results. It will be noticed that although 49 out of 58 trees were sprayed with 20 per ct. kerosene the scales were not killed in any instance except one, and that was on four peach trees that were killed by the oil and the scales died with them. In every case where 40 per ct. and higher percentages were used the scales were killed.

SPRAYING EXPERIMENTS TO DETERMINE THE EFFECTS OF SUMMER APPLICATIONS OF KEROSENE OIL UPON HEALTHY BEARING CANES AND BUSHES.

In these experiments two grades of kerosene oil, 100° and 150° fire test, were used, as follows:

Series Ia.—In this test 100° fire test oil was used on healthy, bearing gooseberry and currant bushes and pear and apple trees. Two applications were made, the first on April 27 and the second on May 5. On the former date the weather was bright with slight wind. Temperature 62°. The average temperature during the week following was 64°. On the latter date the weather was hazy, partially cloudy, slight wind, temperature 56. Average temperature during the week following 61°.

TABLE VII.—BEARING BUSHES SPRAYED WITH 100° FIRE-TEST KEROSENE.

Bushes. Kind.	No.	Percentage oil.	Results.	Checks.
GOOSEBERRIES:				
27 varieties,	27	25	Burning of foliage varied from one-fifth to three-fourths, injured leaves dropped early, thus weakening bushes; latter wintered poorly; about half died next spring.	Two to 5 bushes of each variety. Nearly all wintered well.
CURRANTS:				
5 varieties,	[1]10	15 25	Foliage slightly burned in all cases; bushes uninjured.	Four bushes of each variety.

[1]Two bushels of each variety sprayed; 15 per ct. oil first application, 25 per ct. second.

The following experiments with pear and apple trees included but one application of oil. The apples were sprayed May 4 and 5. The weather was bright, slight wind, temperatures May 4, 54°, May 5, 56°. Average temperature during the following week 60°. The pears were sprayed May 12. The weather was bright with a strong wind. Temperature 64°. Average temperature during the following week 55°.

TABLE VIII.—BEARING APPLE AND PEAR TREES SPRAYED WITH 100° FIRE-TEST KEROSENE.

Trees.[1] Kind.	No.	Percentage oil.	Results.
APPLE:			
Greening and Baldwin.	10	15	May 9 small percentage of leaves killed.
Greening and Baldwin.	16	25	May 9 a little less than one-third of leaves killed.
Greening and Baldwin.	17	40	May 9 from one-third to one-half of leaves killed. Bark somewhat discolored near base of larger limbs.
Greening and Baldwin.	10	60	May 9 about two-thirds of leaves killed. Bark discolored on many of the limbs.
Greening and Baldwin.	10	100	Nearly all of the leaves killed. Also some of the small branches. The bark on the large limbs and trunk injured in spots but not enough to seriously affect the tree. All of the trees put out new foliage.
DWARF PEAR:			
Principally Bartlett.	40	15	No injury to leaves or bark except in a few cases where the nozzle was held in one place too long. This injury was very slight.

Series Ib.—In these experiments 150° fire-test oil was used on healthy, bearing apple and pear trees. One application was made on one lot of apples on June 4 and 5, and on another lot June 10. Weather cloudy, wind mild, temperature 66°. Average temperature during week following 73°.

[1]Full size trees.

Trees.[1] Kind.	No.	Percentage oil.	Results.
Apple:			
Principally Baldwin and Greening.	10	20	No injury.
Principally Baldwin and Greening.	3	15	No injury.
Principally Baldwin and Greening.	2	25	No injury.
Principally Baldwin and Greening.	2	40	No injury.
Principally Baldwin and Greening.	1	50	No injury.
Principally Baldwin and Greening.	1	60	No injury.
Principally Baldwin and Greening.	1	100	Slight burning of the foliage.
Pear:			
Dwarf Bartlett.	4	15	No injury.
Dwarf Bartlett.	4	25	Very slight burning of foliage on windward side.

Summary.—These experiments show, principally, the difference between the 100° and 150° oils in their effects on apple and pear trees. The former injured the foliage in all cases, even with 15 per ct., and when used at 60 per ct. and above seriously injured the bark as well. The 150° oil did not injure the trees except when used pure, when the foliage was slightly burned.

GENERAL SUMMARY AND DISCUSSION OF RESULTS.

The results taken as a whole indicate that peach and plum trees are more susceptible to injury by kerosene oil than apple and pear trees. Peach trees were the most sensitive, being killed by the lowest percentage (20 per ct.) used. The experiments to determine the percentage of high grade oil required to kill the scales showed very definitely that a 20 per ct. mixture had practically no effect, but that a 40 per ct. mixture killed the scales in every case. Kerosene oil of 100° fire test proved dangerous to apple foliage at a percentage as low as 15, while 150°

[1]Trees in full bearing.

oil did not injure the foliage except when used pure and then only slightly. So far as could be ascertained, temperature and weather conditions had little effect on the results, as the effects of spraying were practically the same under varying conditions of heat and cold, sunshine and cloudy skies.

The results of these experiments are also sufficiently definite to indicate that kerosene oil may be used during the winter on apple and pear trees at a percentage (40 per ct.) strong enough to kill the scale without endangering the tree; but that it is impracticable for use on peach trees and dangerous to plum trees.

II. METHODS OF COMBATING THE SAN JOSÉ SCALE.

There are two principal methods of combating the San José scale in the orchard: First, fumigating the infested trees with hydrocyanic acid gas; and second, spraying with some caustic substance that will penetrate the scale and kill the insect beneath or seal it over so firmly as to entirely smother it.

FUMIGATION.

Fumigation is practicable only for comparatively small trees that can be safely cut back to about twelve feet in height and about eight feet in diameter. Either a tent or a canvas box may be used. The former is likely to be unsatisfactory because of the difficulty in accurately estimating its cubic contents and the trouble involved in handling. The box fumigator[1] avoids these difficulties and if not too large is more satisfactory. A modification of the box type has been used by Prof. W. G. Johnson[2] with reported success. It consists of a box which is let down over the top of the tree by means of a mast and pulley. The top of the box consists of a canvas hood which adjusts itself to the height of the tree. The cubic contents of the rigid part of the box can be easily ascertained and the cubic contents of the extended hood estimated.

[1] A form of box fumigator is described in Bulletin 181 of this Station.

[2] U. S. Dept. Agr. Div. Ent., Bul. 20, n. ser., pp. 43–45.

The amount of cyanide to use.—The amount of cyanide to use depends upon the strength required and the size of the tent or box. For fumigating orchard trees in winter use 0.3 gram of cyanide per cubic foot of space inside the tent or box. For example, suppose a tree is to be fumigated with the box fumigator described in our Bulletin No. 181. This fumigator measures 10×6×6 feet. It contains, therefore, 360 cubic feet. We wish to use the gas at a strength of 0.3 gram of cyanide per cubic foot. The amount of cyanide required would then be 360×0.3=108.0 grams[3] or 3.51 oz.

After reducing to ounces use one and one-half times as many fluid ounces of sulphuric acid as cyanide, and one and one-half time as much water as acid. This would make the formula for fumigating a tree in a 10×6×6 ft. fumigator with gas containing 0.3 gram of cyanide per cubic foot as follows:

Cyanide of potassium 98–99% pure..........	3.51 oz. avoir.
Sulphuric acid	5.27 fl. oz.
Water	7.90 "

The exact amount of acid is not important. A small fraction of an ounce will make no difference. In this case 5 oz. would answer the purpose or if preferred 5½ oz. could be used. Likewise eight ounces of water could be used in place of 7.9 ounces. The water should first be placed in the generating dish, which should be a flat-bottomed, open dish, preferably earthenware, the acid being added slowly. When all is ready, drop the cyanide into the dish. A very convenient way to handle the cyanide is to measure it out in small Manila paper bags and when ready to set off the charge drop the bag with the cyanide into the acid.

Cyanide of potassium can usually be had for about 33 cts. a pound and commercial sulphuric acid by the carboy (about 12 gallons) at 1½ cts. a pound. At these prices the cost of the chemicals to fill the above fumigator with gas containing 0.3 gram of cyanide per cubic foot would be about 7½ cts.

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[3]One gram is equivalent to .03257 oz. avoirdupois.

Caution.—Cyanide of potassium is a deadly poison and hence should be properly handled and labeled. When exposed to the air for a few hours it absorbs moisture; it should therefore be kept in a tight box in a dry place. Hydrocyanic acid gas is also very poisonous and hence, when fumigating, the operator should be careful that the tent or box has aired for a few minutes before he goes inside.

SPRAYING

A large number of mixtures have been tested with a view to ascertaining a satisfactory wash to destroy the scale. At present three are considered the most satisfactory here in the East, namely, kerosene oil, crude petroleum and whale-oil soap solution.

A discussion of kerosene oil is given in the first part of this bulletin.

Crude petroleum.—Crude petroleum can be obtained from any dealer in kerosene oil. The quality that seems to determine its value as a safe insecticide is its specific gravity which should not be less than 43° (Beaumé oil scale) at 60° F. Oils of lower specific gravity have been found to be more dangerous to the trees.

Method of application.—Crude petroleum may be applied pure or mixed with water by means of a machine especially designed for the purpose. In either case care should be taken not to apply too much. The object of the spraying should be to cover every part of the tree above ground with as thin a film of oil as possible. If it is mixed with water by means of the pump, use at least 40 parts of oil to each 60 parts of water making a mixture containing 40 per ct. oil.

When to apply.—Late winter or early spring is probably the best time to apply the oil but more experiments are needed to determine this point. In any case it will be better not to apply it after the buds have begun to swell; for although this has been done in some cases without apparent injury, in others it has ruined the trees. Summer application should be avoided. Care should be taken not to put too much on the trees and to make

the applications uniform. The spray should be applied until the trees begin to drip slightly.

Caution.—Peach and Japan plum trees are more liable to injury by crude petroleum than either European plums or pears and apples. It is also to be borne in mind that the full extent of the effect of the oil on the tree is not always apparent the first season—but may require a second season to show the full extent of the injury if there is any.

Whale-oil soap.—Whale-oil soap is one of the safest insecticides that can be depended upon to kill the scale. A caustic soda soap is preferable to a caustic potash soap. Although the price fluctuates somewhat it can usually be obtained in 100 pound lots at about 4½ cts. a pound.

The soap should be dissolved in hot water using two pounds to the gallon, and should be applied to the trees as hot as possible. The treatment should be made during the winter.

REPORT

OF THE

Horticultural Department.

S. A. Beach, *Horticulturist.*

Wendell Paddock,[1] *Assistant.*

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Table of Contents.

[1] Resigned September 15, 1900.

[2] Appointed November 1, 1900.

FUMIGATION OF NURSERY STOCK.*

S. A. BEACH.

INTRODUCTION.

The best known way of killing San José scale on dormant nursery stock is by fumigation with hydrocyanic acid gas.[1] This treatment is valuable not only against San José scale but against all scale insects which do not winter in the egg stage. It will doubtless also check the spread of some other kinds of injurious insects which are liable to be distributed on nursery stock.

Plain directions for fumigating dormant nursery stock with hydrocyanic acid gas will first be given, after which suggestions will be made as to the location and construction of fumigation houses or chambers.

APPARATUS, MATERIALS AND METHOD.

THE EQUIPMENT.

The things needed for fumigating nursery stock with hydrocyanic acid gas are: (1) The chemicals; (2) a suitable dish in which to mix them; and (3) an air-tight box or chamber to hold the stock while it is being fumigated.

CAREFUL WORKMEN NEEDED.

It is not hard to kill the San José scale; the difficulty is to kill it without injuring the plant upon which it is living. The scale insect is fastened immovably to the plant with its mouth parts stuck into the bark so that it may suck the plant juices which constitute its food. It cannot be given poison in its food, but must be killed by something which comes in contact with its

*Reprint of Bulletin No. 174.

[1]This substance is commonly known in liquid form by the name "prussic acid."

body. Exposing it to hydrocyanic acid gas kills it if the fumigation is properly done. Too great an amount of the gas will injure the plant. If the gas is too weak or the time of exposure too short, the scale insects may not all be killed. It is very important, therefore, that the work be done only by intelligent and careful workmen.

DANGER TO HUMAN LIFE!

But there is a still stronger reason for keeping this work always under the direction of a competent person, and that is because *hydrocyanic acid gas is most deadly poison.* One full breath of it may at once stop the action of the heart. A large dose may cause instantaneous death.

THE CHEMICALS.

Water, sulphuric acid and potassium cyanide are the chemicals needed for making hydrocyanic acid gas.

Sulphuric acid (H_2SO_4).—A good grade of commercial sulphuric acid should be used. Its specific gravity should not be less than 1.82. At present it costs less than two cents a pound, wholesale. Care should be used not to spill the sulphuric acid upon either the clothing or the person. It eats the clothing and burns the flesh.

Potassium cyanide (KCN).—The fused cyanide 98 to 99 per ct. pure should be used. It is now supplied by the manufacturers in wholesale quantities for about 30 cents per pound. Somewhat higher prices are quoted by dealers. It is a white, solid substance, which absorbs moisture and gradually vaporizes unless it is kept from the air. It is best to keep it in air tight cans, plainly labeled "poison," and put where children or others who may not know its deadly character cannot get it.

Potassium cyanide is one of the most poisonous substances known! Instances are on record where adult persons have been killed by five grains, which would make a lump about the size of a large pea. The vapor from the can in which potassium cyanide is kept is also poisonous.

THE FUMIGATION.

When the stock has been put into the fumigation chamber, place a glazed earthen-ware dish having a capacity of a gallon at least on the floor near the middle of the room. If the room is large use one large gas generator in each 1000 cubic feet of space, or use several smaller ones properly distributed.

To generate the gas, first pour into the dish the required amount of water, then add the sulphuric acid. This process should not be reversed because when the water is poured into the acid a more violent action takes place and the acid is liable to be spattered upon the person doing the work. Lastly drop into the dish the paper containing the potassium cyanide. Get out of the room and close the door as quickly as possible *being very careful not to get a breath of the gas*. From the time fumigation begins till the room has been thoroughly ventilated a DANGER placard should be displayed at the door.

Time.—The entomologists who have investigated this subject are not yet agreed as to the length of time which should be recommended for the fumigation of dormant nursery stock but they generally give from 30 to 50 minutes. Sirrine advises that, when using the formula given below, the stock be fumigated for one hour. In Johnson's tests, well matured stock of apple, plum, etc., stood treatment one hour with gas at a strength far above the standard used; so that in general with the standard strength, no damage need be feared from an overdose with well-matured stock.[2] It is well to be on the safe side and continue the fumigation long enough to secure the full benefit of the operation.

Ventilation.—After the stock has been fumigated the room must be ventilated for *at least ten minutes* before entering it. This rule must be strictly enforced because anyone who enters the room before it has been properly ventilated *endangers his life*.

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[2]Johnson, W. G. Some physiological effects of hydrocyanic acid gas upon plants. Sci. Amer. Sup., 48 : 20026.

THE FORMULAE.

The following formula is recommended by Sirrine for general use in fumigating well-matured dormant nursery stock. For each 100 cubic feet of space in the room use:

FORMULA FOR WELL-MATURED STOCK.

Potassium cyanide, 98 to 99% pure	1⅛ oz. (avoir.)
Sulphuric acid[3]	1⅜ to 1½ fl. oz.
Water[3]	4½ fl. oz.

Fumigate for one hour and then ventilate the room ten minutes before entering it.

Sirrine's experiments with different amounts of the cyanide lead him to the opinion that for general use with well matured nursery stock the amount should not be less than 1⅛ oz. per 100 cubic feet, which is the amount given in the above formula.[4] He finds, however, that stock, under some conditions, is injured by even as small a quantity of the cyanide as this. Johnson reports similar results and recommends for peach whips, June budded peach trees, bud sticks and in general all stock which is not well matured, that the amount of potassium cyanide be reduced to 18 grams (approximately ⅝ oz.) per 100 cubic feet.[5] When stock is to be fumigated which is not well matured it is doubtless best to reduce the amount of the cyanide as Johnson recommends, even if it is necessary to lengthen the time of fumigation to get satisfactory results. Following Sirrine's ideas in regard to the proportionate amounts of sulphuric acid and water the formula for each 100 cubic feet of space would be as stated below.

[3] In this formula Mr. Sirrine recommends more sulphuric acid and water to each ounce of potassium cyanide than is called for in some other formulæ which have been recommended by other entomologists.

[4] Other entomologists recommend less amounts of the cyanide. Johnson's formula calls for approximately 9/10 oz. per 100 cubic feet; Alwood uses 1 oz., Marlatt 1 oz. and Webster ⅘ oz. per 100 cubic feet for well matured stock.

[5] Johnson, W. G. l. c.

FORMULA FOR IMMATURE STOCK, BUD STICKS, ETC.

Potassium cyanide, 98 to 99% pure..........	5/8 oz. (avoir.)
Sulphuric acid	3/4 fl. oz.
Water	2½ fl. oz.

REFUMIGATION.

Johnson finds that the peach will not stand a second fumigation. Apple, pear, etc., are not injured by it, but it is well not to expose stock a second time to the gas after it has been once properly fumigated.

FUMIGATION OF STOCK NOT DORMANT.

Stock which has passed out of the dormant condition cannot be safely fumigated with gas at the strength given for dormant stock, neither can it in the fall before the leaves have dropped.

THE FUMIGATION HOUSE.

The first essential in building a room or box to be used in the fumigation of nursery stock is to make it *air tight*. If the room is not air tight the results will be uncertain and surely unsatisfactory.

It is also important that the room or house be so located that it can be readily ventilated without having the escaping gas interfere with other work. It is best to provide for ventilation by flues opening through the roof. This is especially desirable where the fumigation chamber occupies a portion of a packing shed or any other building which is filled with workmen during the fumigating season.

Figures 10 and 11 give different views of a very satisfactory fumigating house used by the R. G. Chase Nursery Co., Geneva, N. Y. It is modeled after the house described in Bulletin 57, Maryland Agricultural Experiment Station, pages 92 and 93. A somewhat detailed description of it is herewith given because it represents a very good type of air tight construction.

The outside dimensions of the building are 16 ft. x 32 ft.; posts 7 ft. and peak of roof 9 ft. high. The studding, which is 2x4 inch hemlock, is covered outside with building paper lapped

one-half, then with upright boards battened with 4 inch strips as shown in the cut. The studding is covered inside with $\frac{5}{8}$-inch ship-lapped lumber; following this is a course of building paper lapped one-half and then the ceiling of matched boards. The floor beams are first covered with matched boards, then with building paper lapped one-half and lastly with matched flooring. The ceiling beams are covered above with $\frac{5}{8}$-inch ship-lapped lumber, and beneath with a course of building paper lapped one-half and then with ceiling of matched boards. The roof is made of surfaced hemlock laid on 2x4 inch rafters and covered with roofing paper. For a permanent building a shingled roof with steeper pitch would doubtless be more economical.

The doors are made after the manner of doors used for cold storage rooms. They should fit perfectly, and it is well to provide weather strips or felt for the edges to press against when the doors are closed. The doors should be firmly supported with strong hinges. At the top of each large room opposite the entrance is a small door $3x2\frac{1}{2}$ ft. as shown in Fig. 11. These are made quite similar to the doors at the entrance. They aid in securing rapid and thorough ventilation. Flues from each large room leading through the roof are made for the same purpose. These are fitted with air tight covers at the top, which are opened from the roof as shown in Fig. 11. They are closed at the bottom by a slide which is reached from the roof through the flue.

The interior is divided into two large rooms and one small one by partitions made of two thicknesses of matched lumber with building paper between. The large rooms are each 15x13 ft. and hold about 3,000 apple trees of $\frac{7}{8}$ inch caliper. The small room, 4x15 ft., is for fumigating smaller lots of stock.

Every detail of work should be performed with the idea constantly in mind of making the building air tight. The sheathing paper must be laid smoothly and evenly and the sheathing boards and ceiling must be free from warps, knots or other defects which impair their value for the purpose for which they are intended.

It is convenient to have a box which will hold about 50 cubic feet for use in fumigating very small lots of nursery stock, bud sticks, scions, etc.; then the chemicals can be used at one-half the strength given for 100 cubic feet. A very convenient form has the inside dimensions 2 ft. x 3 ft. x 8 ft. It is long enough to hold ordinary sizes of nursery trees. It may be made air tight by using building paper and matched boards after the manner just described for the fumigating house. It should have an opening low down on one side through which the cyanide may be dropped into the acid after the top of the box has been tightly closed. This opening should be closed by a tight fitting slide as soon as the cyanide has been put into the acid.

Some fumigating houses are made large enough so that a wagon loaded with nursery stock can be run into the fumigating room. Where this plan is followed the floor of the wagon box or rack should be open enough to allow the gas to pass readily to the lowest part of the load. The fumigation requires no less amounts of the chemicals when there are not enough trees to fill the room. In such a house as this the cost of filling the empty space with gas is so great that some nurserymen believe it is more economical to unload the wagon and fill the room with stock, leaving the wagon outside.

ACKNOWLEDGMENTS.

The writer desires to acknowledge with thanks the courtesies extended to him and assistance rendered in the preparation of this bulletin by Mr. F. A. Sirrine, Entomologist for this Station at Jamaica, N. Y.; Mr. E. B. Hart, Assistant Chemist, Geneva, N. Y.; Professor W. G. Johnson, Entomologist of the Maryland Agricultural Experiment Station, and Mr. C. L. Marlatt, First Assistant in the Division of Entomology, Washington, D. C.

THE NEW YORK APPLE-TREE CANKER.*

(SECOND REPORT.)

WENDELL PADDOCK.

SUMMARY.

Attention is called to the fact that the canker fungus, *Sphæropsis malorum* Pk., occurs on several hosts; viz.: Apple, pear and quince fruits, and apple trees, pear trees and hawthorn trees. It is probable that species of *Sphæropsis* occurring on a number of other hosts are identical with this, but inoculation experiments have not yet been carried far enough to show that this is so.

Sun scald and sun burn undoubtedly have much to do with the susceptibility of some varieties of apple trees to canker.

Spraying the trees in winter with a whitewash protects them to some extent from the heat of the sun's rays, and is a partial preventive of sun scald.

Training the trees to thick, low heads, which afford shade for trunks and branches in summer is a partial preventive of sunburn.

Spraying with Bordeaux mixture is recommended as a partial preventive of canker.

Nectria ditissima, a serious canker fungus of European orchards, has been found on apple trees in New York and in Nova Scotia.

INTRODUCTION.

Previous to the publication of Bulletin 163 of this Station the New York apple-tree canker was scarcely known. The injuries had attracted the attention only of the more observing and were

*Reprint of Bulletin No. 185.

Plate LIII.—Sphaeropsis on Apple: 1, Branch Girdled at *a* and Injured at *b* by Cankers; Saprophytic Fungi at *a* also; 2, Same with Dead Bark Removed; 3, Typical Canker; 4, Bark Showing Pycnidia Natural Size.

PLATE LIV.—SPHAEROPSIS INOCULATIONS ON PEAR: 1, FROM APPLE FRUIT; 2, CHECK; 3, FROM APPLE TREE.

1 2 3

Plate LV.—European Canker: 1, Recent Infection; 2 and 3, Old Cankers.

regarded usually by them as being the result of sun scald, or as a condition peculiar to the growth of certain varieties of apple trees. It was only necessary, however, to call the attention of orchardists to the disease and to make known its appearance and effect, when it was recognized and found to be a serious pest in most of the apple-growing sections of the State.

While the bulletin above mentioned gives the results of two years' work with the fungus, it is incomplete; since many questions arose that could not be answered. The work was continued through the season of 1900 and a few more facts were established which add to our knowledge of the disease.

EFFECTS OF THE DISEASE AND APPEARANCE OF AFFECTED PARTS.

A brief discussion of the work of the fungus and the appearance of cankered limbs will not be out of place at this time; but for a fuller discussion of the subject the reader is referred to the former bulletin.

Any part of the trees above ground, with the possible exception of the leaves, may be attacked by the canker fungus which has been proven to be *Sphæropsis malorum* Pk. When the larger limbs, or in rarer instances, the trunks, are attacked, the injuries are known as cankers. Such injuries are often quite conspicuous since the bark becomes thick and rough, and saprophytic fungi soon gain a foothold causing the parts to turn black. (See Plate LIII.) The injuries are often several feet in length; and because of these striking characters, cankered limbs may be recognized at a considerable distance.

The fungus may live in the outer bark, but here it does little harm, and true cankers are formed only when it gains entrance to the cambium layer. Under favorable conditions the fungus spreads until a considerable area of bark is destroyed. The limb may be girdled by the fungus, but borers and saprophytic fungi often complete the work of destruction. An affected branch may live for a number of years and bear fruit, but if the wound

is large the normal activity of the branch is seriously interrupted. The swelling of the bark is probably caused by an excess of food being deposited, as a result of the partial girdling of the limb.

When the twigs are attacked a portion of the new growth may be killed in much the same manner as when attacked by pear blight. Much damage may result from such attacks and the fungus may occur in orchards where there is no evidence of cankers on the larger limbs.

Black rot of apples was first brought to the attention of the public by Dr. Chas. H. Peck [1] in 1881. Since then the disease has been found also on pear and quince fruit; and at the present time black rot is a common orchard disease. Several experimenters have proven the identity of the fungus as it occurs on the three hosts. Our experiments prove that the black rot fungus and the canker fungus are identical.

The leaves of apple trees are occasionally attacked by a *Sphæropsis*, when injuries appear in the form of round brown dead spots somewhat like those from burning by improper spraying with Paris green. This form of *Sphæropsis* has not been definitely proven to be identical with *S. malorum*, but the indications are that it is the same.

EXPERIMENTS IN 1900.

The inoculation experiments with cultures of the canker fungus were continued for the purpose of confirming former results and to determine, if possible, the relationship between the *Sphæropses* that occur on various plants. Cultures were made from cankered apple-tree limbs and from decaying apples. Trees of various kinds were inoculated with these cultures, as given in the table below. A flamed scalpel was used in making incisions in the bark, then some of the fungus as it had developed in the cultures was inserted in the wounds. Check wounds were made in the same manner but not inoculated, and all wounds were protected with grafting wax. (See Plate LIV.)

[1] Ann. Rept. N. Y. State Mus. Nat. Hist., 1881, p. 36.

Table I gives the plan and results of the experiments, and includes: Hosts from which cultures were obtained; kinds of trees inoculated; number of inoculations made; growth of fungus where inoculated.

TABLE I.—GROWTH OF SPHÆROPSIS FROM DIFFERENT SOURCES ON DIFFERENT HOSTS.

	Hosts from which cultures of *Sphæropsis* were obtained.	Kind of tree inoculated.	Number of inoculations made in each tree	Growth fungus.
1	Apple tree	Apple tree	4	Very good
	Apple fruit		4	"
	Check		4	0
2	Apple tree	Pear tree	4	Very good
	Apple fruit		4	"
	Check		4	0
3	Apple tree	Hawthorn *Cratægus oxyacantha*	4	Very good
	Apple fruit		4	"
	Check		4	0
4	Apple tree	Apricot (Russian)	4	0
	Apple fruit		4	0
	Check		4	0
5	Apple tree	Peach tree	4	0
	Apple fruit		4	0
	Check		4	0
6	Apple tree	Sumach	4	0
	Apple fruit		4	0
	Check		4	0
7	Apple tree	Persimmon	4	0
	Apple fruit		4	0
	Check		4	0
8	Apple tree	Hop hornbeam	4	0
	Apple fruit		4	0
	Check		4	0

Cultures of *Sphæropsis* as obtained from all of the hosts given in the table, save from the peach, were experimented with the previous season, and all were found to produce black rot of apple fruits readily, and all made some growth when inoculated into apple and pear nursery trees. Table I shows that, on the other hand, the canker fungus refused to grow when inoculated into apricot, peach, sumach, persimmon or hop hornbeam trees. Further experimenting will be necessary before the full significance of these negative results will be understood, but two ways of accounting for them come to mind. The first is that these hosts are, as has been supposed, attacked by different species of *Sphæropsis*. In this case, apple fruits must be regarded as a very favorable medium for the growth of these

different species, and to a lesser extent the same will be true of apple and pear trees. The second explanation is that *Sphæropsis* is not parasitic on these trees.

The statement was made in Bulletin 163 that the so-called species of *Sphæropsis* occurring on apple bark and on decorticated apple wood are identical and that they are also identical with the black rot fungus of apple, pear and quince fruits, *Sphæropsis malorum* Pk. It can now be stated that as a result of experiments extending through three seasons we have positive evidence that this *Sphæropsis* occurs on apple trees, pear trees and hawthorn trees and on apple, pear and quince fruits and will grow as well on one host as on another. There is then, no reason for maintaining separate species for the fungus as it occurs on these hosts.

The results also indicate that there are still other hosts for the fungus, but further experimentation will be necessary before they will be definitely determined.

SUN-SCALD, SUN-BURN AND CANKER.

On page 188 of Bulletin 163 reference is made to the occurrence of sun-scald, or winter injury, and its connection with the canker fungus. After becoming somewhat familiar with orchards in a state where sun-scald is a menace to all kinds of fruit trees, the writer is convinced that this condition is much more common in New York orchards than is commonly supposed. The longitudinal areas of reddish bark often seen on the south and southwest sides of trunk or limb are an indication of sun-scald. The tissues of this discolored bark have been killed by sun and frost. At the approach of warm weather, fermentation may set in and a sour odor be given off from the affected parts. A number of trees of the more tender varieties in the Experiment Station orchards have been ruined by sun-scald and at the present time the orchards contain several trees that are seriously injured. Such injuries may be looked for in any part of the State.

No variety of apple is more susceptible to canker than the Esopus (Spitzenburg) although a few New York orchardists are growing this variety to perfection. After an inspection of the trees, we are inclined to the opinion that the Esopus trees, as well as some other kinds, are easily injured by the sun's rays in summer. Such injury is also common to various cultivated trees in many parts of the west, where it is known as sun-burn.

The canker fungus finds access to the living tissue through such injuries and though the injured area itself is small it may soon be greatly extended by the growth of the fungus.

In some parts of the west, orchardists spray their trees during the winter with a whitewash as a protection against sun-scald. Whitewash has been used to some extent to prevent the premature swelling of fruit buds in spring and it has been found to be some protection against winter injury as well. That the action of the lime may also have a beneficial effect on the trees is shown by instances in which a healthy condition of the bark has followed its use.

The formula given below is recommended by the best authorities for a winter wash. The tallow and salt render the mixture very adhesive so that it is not readily washed off by winter rains.

Lime (unslaked)	30 pounds.
Tallow	4 "
Salt	5 "

Dilute with enough water to make it spray easily through a moderately fine nozzle.

Heading the trees low so as to protect the trunk from the sun and forming a thick head for the purpose of shading the branches, help to prevent sun-burn.

THE TREATMENT OF APPLE-TREE CANKER.

The experiments in treating a canker-infested orchard were continued through the season just closed and again we must report that no definite results were obtained. However, it is too much to expect that flattering results will attend a spraying

experiment of this kind, since old infections cannot be cured and new ones are not rapidly formed.

Another year's observation confirms the recommendations made last year in regard to spraying with Bordeaux mixture, with good orchard sanitation, as a preventive of apple-tree canker. The presence of this disease in neglected orchards and its absence in orchards that have been well sprayed and well cared for in general, is strong evidence that with most varieties the disease may be easily controlled; but with some of the more susceptible kinds as the Esopus and the Twenty Ounce it is quite probable that the conditions known as sun-scald and sun-burn must be overcome before the canker fungus will be successfully combated.

Another point of practical importance not mentioned in the former bulletin is the method that some orchardists have adopted for saving the larger diseased limbs. This is done by sawing the limb off just back of the diseased area and then inserting cions of the same variety.

MACROPHOMA AND APPLE-TREE CANKER.

In Bulletin 163, page 203, *Macrophoma malorum* (Berk.) Berl. et Vogl., is mentioned in connection with the body blight of the pear. This fungus is very common on both apple and pear trees and during the past season a number of cankered apple-tree limbs were found on which the injuries were evidently due to its attack.

After repeated trials the fungus was finally induced to grow luxuriantly in test tube cultures where it fruited abundantly. The spores germinate readily in potato agar, but make very little growth. When transferred to sugar beet plugs they made better growth, but produced no spores. The method finally adopted was to make plate cultures of the spores when they were located under the microscope, then transfer to sterilized bean stems in test tubes.

This *Macrophoma* resembles *Sphæropsis malorum* Pk., closely in all respects except that the spores are hyaline, the spores of *Sphæropsis* being dark. Saccardo even suggests that it may be an immature stage of that fungus. But since the spores are still hyaline when germination takes place and, after sufficient growth, they in turn produce hyaline spores, there is no doubt as to the distinction between the two species.

Numerous inoculations were made in both apple and pear trees with cultures of the *Macrophoma* from both of these hosts, but in no instance were positive results secured. These experiments should be repeated, however, before deciding that the fungus is not parasitic.

THE EUROPEAN CANKER.

Mention is made in Bulletin 163 of the canker fungus, *Nectria ditissima*, which is a common and serious orchard disease in many parts of Europe. *N. cinnabarina* is also mentioned as having been found on quince trees in an orchard near Geneva and an illustration is given of the injury that is produced. This species is quite common in America, but is not regarded as being particularly injurious. Up to this time the former species had not been recorded as occurring on apple trees in America, but during the past season specimens of apple limbs were received at the Experiment Station which proved to be infected with this fungus.

The following account of this disease is quoted from *Science*.[2]

"Shortly after Bulletin No. 163 of this Station, entitled 'A New York Apple Tree Canker,' was distributed, the writer received specimens of diseased apple limbs from various parts of the United States and Canada. Among the rest was a specimen from Nova Scotia which was noticeably different from any that I had yet seen. The injury was about six inches long on a limb two inches in diameter. Within the diseased area was

[2] Paddock, W. European Apple Tree Canker in America. Science, 12 : 297–299.

a series of six ridges or convolutions in the wood surrounding a central starting point, each one of which evidently marked a year's growth of a parasitic fungus. The fungus, *Sphæropsis malorum* Pk., which has been shown to be the cause of the common New York apple-tree canker, is more active in its growth. With this disease large areas of bark may be destroyed and the wood laid bare, or in other instances the bark may be much swollen and roughened, but the form of injury described above does not occur.

The appearance of the diseased limb, which was similar to that shown in Plate LVI at 3, strikingly resembled the work of *Nectria ditissima* as illustrated and described by European writers. However there was no fungus fruit in evidence, and as I was unsuccessful in obtaining more specimens the matter was dropped for a time.

In the latter part of May several specimens of diseased apple limbs were received from East Homer, Cortland County, N. Y., that were similar in appearance to the one from Nova Scotia, but in addition many portions of the dead bark and wood were thickly studded with the minute, deep red perithecia of a *Nectria*. Among the specimens were examples of recent infections as is shown at 1, in the plate, as well as cankers of several years standing. The perithecia were abundant on all these specimens, so there seemed little doubt but that the *Nectria* was the cause of the diseased condition.

On visiting the locality it was found that the fungus was evidently confined to a small area and but few additional specimens were secured.

Through the kindness of Professor F. C. Sears, Wolfville, N. S., more specimens of the diseased apple limbs were obtained from that locality in June and the perithecia of the *Nectria* were found to be abundant on them. Professor Sears writes that this form of canker is doing serious damage in some of the orchards of the Annapolis Valley.

Specimens of the diseased branches were sent to Dr. R. Hartig, Munich, Germany, for identification, who writes that the cankers are caused by the fungus *Nectria ditissima*.

So far as I know this fungus has not as yet been recorded as occurring on apple trees in America, and its appearance in our orchards is of great practical importance since it is a serious pest to European fruit growers."

Since the above article was written, I have had an opportunity of comparing the fungus with specimens of *N. ditissima* on cankered apple trees which were collected for me in England by Mr. H. Hadlow of this Station. There is no doubt as to its identity.

SPRAYING IN BLOOM.*

An Account of Laboratory and Field Experiments by the New York Agricultural Experiment Station, Geneva, N. Y.; Including also the Results of Field Experiments by the Cornell University Agricultural Experiment Station, Ithaca, N. Y.

SUMMARY.

RESULTS OF INVESTIGATIONS BY THE CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION, ITHACA, N. Y.

The field experiments conducted by the Cornell Experiment Station show no decisive results from spraying apple trees when in bloom. This is probably because the year 1900 was one of heavy crop and of little disease, and good or fair crops followed all treatments and even no treatment. It is significant, however, that thorough spraying when in bloom did not seem to diminish the crop.

There was no apparent injury to the blossoms on trees sprayed when in full bloom.

RESULTS OF INVESTIGATIONS BY THE NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

During the season of 1900 the Station commenced an investigation of the effect of spraying fruit trees when in bloom with the mixtures commonly used in fighting insects and diseases in orchards. Studies of the effect of the spray mixtures on the

*Reprint of Bulletin No. 196.

germination of pollen and the growth of pollen tubes were made in the laboratory; and in the orchard the effects of spraying the trees when in full bloom were observed.

The spraying mixtures and even the lime alone prevented the growth of pollen in weak aqueous solutions of sugar.

In Bordeaux mixture, 1 to 11, diluted with a weak aqueous sugar solution to only 200 parts in 10,000, pollen rarely germinated; 100 parts in 10,000 in some cases wholly prevented the germination of pollen; 50 parts in 10,000 in some cases wholly and in others partly prevented the germination of pollen, and always much retarded and dwarfed the growth of the pollen tubes. Even 2 parts in 10,000 sometimes had an adverse influence on the germination of the pollen.

Where apple blossoms, in the earlier part of the blooming season, were hit by a spray of Bordeaux mixture combined with an arsenical compound, they generally failed to set fruit. Blossoms which had been open several days before they were hit by the spray seemed to have reached a stage where this treatment did not check the setting of fruit. Apparently conflicting results are reconciled by a clear understanding of this point. There is a great difference between young blossoms and old blossoms in their susceptibility to injury by spray mixtures.

By spraying repeatedly during the blooming season, thus hitting the new blossoms as they opened from day to day, the blossoms were nearly all destroyed and as a consequence scarcely any fruit set.

A number of sprayed blossoms were observed which had some of the spray mixture on the stigmatic surface. None of these set fruit.

During the season of 1900 the orchards under experiment were so free from attacks of apple scab and other fungous diseases that no information was gained as to whether or not such diseases may be controlled better by spraying in bloom than by earlier and later treatments.

Even with trees which had a great abundance of blossoms spraying but once during the blooming season decreased the

yield on the average from one-third bushel to one and a half bushels per tree.

Spraying in bloom, while it thinned the fruit, did not always decrease the amount of marketable fruit.

The evidence indicates that spraying in bloom has the effect of thinning the fruit if the treatment is given soon after the blossoms open. Should the trees have but little bloom it would seem, therefore, that such spraying might cause a decided loss in yield of marketable fruit. Further experiments however, are needed before this point may be considered as thoroughly established.

INTRODUCTION.

S. A. BEACH.

The practice of spraying fruit-bearing plants in bloom, especially apple trees, started a few years ago. Among some of the fruit-growers in this State it soon spread to such an extent that the bee-keepers became alarmed at the prospect of serious injury to their interests by the wholesale poisoning of the bees which might visit the sprayed blossoms. Accordingly they succeeded in 1898 in securing the enactment of a law making it a misdemeanor to apply any poisonous substance in any way to fruit trees in bloom.[1]

Some of the fruit-growers who had come to believe that better results could be gained by spraying in bloom than by spraying at any other time were very much opposed to the law and tried to

[1] CHAPTER 325, LAWS OF 1898.

An act to prevent the application of poison to fruit trees while in blossom.

The people of the State of New York, represented in Senate and Assembly, do enact as follows:

SECTION 1. Any person who shall spray with, or apply in any way, poison or any poisonous substance to fruit trees while the same are in blossom, is guilty of a misdemeanor, punishable by a fine of not less than ten dollars nor more than fifty dollars.

SECTION 2. This act shall take effect July first, eighteen hundred and ninety-eight.

get it repealed. So firmly convinced were they of the advantages of the prohibited way of spraying that they appealed to the Cornell University and New York Agricultural Experiment Stations, at Ithaca and Geneva, respectively, to make tests comparing spraying in bloom with spraying at other times. The Station Directors replied that such tests could not be made without violating the law. The matter was then presented to the legislature with the result that the law was so amended as to permit the experiment stations to spray trees in bloom for experimental purposes. We have seen no record of any systematic tests along this line excepting the accounts of work on those phases of the question which relate to the poisoning of bees by spraying poisons on the blossoms, and to the part bees play in the setting of fruit.

The problem which the stations have been asked to solve is not a simple one. These are some of the questions which it brings up:

1. Does spraying in bloom give superior protection to the fruit against the attack of insects and diseases?
2. Does it increase the yield?
3. What is the effect on blossoms which are hit by the spray?
4. To what extent are insects helpful in setting fruit?
5. What is the effect on insects which visit the sprayed blossoms?

The results of the investigations which were conducted in 1900 are conclusive on some points. This is especially true of the laboratory tests. The field tests, however, are generally inconclusive as to the practical results of spraying orchards in bloom.

When the conditions of the season of 1900 are considered in relation to the points under investigation it is not surprising that the tests of the influence of the treatment on the yield were not altogether conclusive. In some seasons the conditions are very favorable to the development of the apple-scab fungus. There is reason to believe that in 1898 this fungus was quite destructive

not only to fruit and foliage, but even to the blossoms of the apple. In 1900, on the contrary, the foliage, blossoms and fruit in the apple orchards of Western New York were generally free from its attacks. The benefit from spraying apple orchards, therefore, was generally much less in 1900 in this section than it was in 1898. The advantage or disadvantage of spraying in bloom may be expected to appear in the most striking manner in a season when the scab fungus and other diseases of foliage and fruit are most aggressive, and when the blossoms are not very abundant. It may be necessary to continue the investigations for several years before satisfactory general conclusions on the subject are established. It is desirable, therefore, to publish this preliminary report to give an account of the progress of the work and to direct the thought of those who are interested in the subject towards the main points which are under investigation.

Professor L. H. Bailey has very kindly offered the results of the field experiments by the Cornell Experiment Station on spraying apple orchards in bloom for publication in this bulletin. Because of this courtesy we are enabled to present in one publication the results of the investigations by both the New York and the Cornell Stations in 1900. The report of the field work by the Cornell Station will be presented first and afterwards the work of this (Geneva) Station will be considered.

I. FIELD EXPERIMENTS OF CORNELL EXPERIMENT STATION ON SPRAYING FRUIT TREES IN BLOOM.

L. H. BAILEY.

There has been much discussion in the past two or three years as to the soundness of the advice that apple trees must not be sprayed when in bloom. It has been said by the experimenters that spraying trees when in bloom gives no additional protection over spraying just before or just after they bloom, that it may interfere with the setting of the fruit, and that it may kill the bees which are considered to be indispensable agents in the

pollination of the flowers. These teachings have been so generally accepted that there is a law on our statute books making it a misdemeanor to spray fruit trees when in bloom because the spraying is liable to kill the bees. In certain parts of the apple-growing regions in Western New York, there has arisen a feeling that better results are to be secured if the trees are sprayed when they are in full bloom; and this belief is founded upon tests made by practical men. Growers who found it impossible to complete the spraying before the trees were in bloom found that the latter-sprayed trees gave better results. The following notes will indicate the origin in Western New York of this belief in the efficacy of spraying apple trees when they are in full blossom. These notes are given here only for the purpose of showing how strong the conviction is in some places, that spraying in bloom is a good practice, and of explaining why the experiment stations have taken up the investigation of the subject.

The beneficial results that are said to follow the spraying of fruit trees when they are in bloom were noticed in Western New York by an apple-grower of Gasport, in 1898. He had planned to spray all his apple trees that year according to spray calendar directions, that is, just before the blossoms opened; but the extent of his orchard and several unavoidable interruptions, including rainy weather, prevented him from doing so. The result was that part of his trees were sprayed before the blossoms opened, part when they were in full bloom, and part after the blossoms had fallen. Bordeaux mixture and Paris green were used in all cases. A second spraying with the same mixture was given after the fruit had set. This grower reported that he had by far the largest crop and finest fruit on those trees that were sprayed when in full bloom, and that the percentage of inferior fruit increased on other trees as they were further removed from this period of spraying. In the same year a smaller orchard owned by this man was sprayed with Bordeaux and Paris green while in full bloom, and again just after the fruit had set. It produced a fine crop of fruit, while other

orchards near by were unproductive. Other fruit-growers of Gasport and vicinity noticed the results of this spraying in 1898, and substantiate the reports. In 1899, therefore, this grower sprayed as much of his larger orchard as he could when the trees were in full bloom, and the results of 1898 were duplicated. Never did he have a larger crop and finer fruit. In 1900, this orchardist sprayed again when the trees were in full bloom. He "aimed to spray every blossom well." "I had twice the amount of apples—over 2,000 barrels—the quality the best I ever had, so that I am convinced more than ever that spraying in the blossom is the time to do it."

Adjoining him is an orchard of nearly the same age and vigor. Until 1898 the two orchards had been about equally productive, with perhaps a little difference in favor of the former. In 1899 the latter grower sprayed all his trees before they had bloomed, but not during the blooming season. Although the trees bloomed as full as the neighbor's that year, they bore but a scanty crop, and the fruit was somewhat inferior to that from the neighbor's trees which were sprayed when in bloom.

Another apple-grower of Gasport sprayed his trees for the first time in 1899. Being then skeptical about the value of spraying, he made a few experiments. Four of these tests are of interest here: (1) Thirty-six trees of Twenty Ounce were sprayed with Bordeaux mixture and Paris green when in full bloom. They bore 224 barrels of No. 1 fruit, an average of 6¼ barrels per tree. (2) Five trees of the same variety which were sprayed after the blossoms had fallen bore five barrels of No. 1 fruit, or one barrel per tree. (3) Three times as many marketable fruits matured on one side of a row of King which was sprayed while in full bloom as on the other side which was sprayed after the blossoms had fallen. (4) The lower limbs of one Baldwin tree were sprayed while in full bloom, and the upper limbs five days later when most of the blossoms had fallen. Only the lower limbs of this tree produced first-class fruit. (5) Five trees of Twenty Ounce were sprayed on one side

when in full bloom and on the other side when the blossoms had fallen. More and better fruit was taken from the side sprayed in full bloom. The whole orchard, including the trees under experiment, was sprayed again with Bordeaux and Paris green when the fruits were as big as marbles. The grower has photographs of the experimental Baldwin and Twenty Ounce trees, showing the difference in their fruitage. In 1900, tests were again made with these trees: 36 trees sprayed in full bloom gave "150 barrels of No. 1 fruit," and 2 trees sprayed when the blossoms had fallen gave "1 barrel of No. 1 fruit and 3 barrels of No. 2 fruit."

A fourth grower of Gasport sprayed part of his orchard in 1899 before the trees blossomed, but was interrupted, so that the remaining trees were not sprayed until they were in full bloom. He had a good crop only on the latter trees.

A fruit grower of Orangeport has an old orchard, mostly Rhode Island Greening, which was in sod till 1899, and had never been productive. That year it was plowed, tilled and sprayed with Bordeaux and Paris Green. As the owner was not able to cover the entire orchard before the blossoms opened, he was compelled to spray a block of 36 trees near the road when they were in full bloom. "Those 36 trees bore more good fruit than the remaining twelve acres in my orchard. I believe it was due to the fact that I sprayed them in full bloom. I am spraying most of my trees this year at that time."

In 1899, another man in Orangeport sprayed all of the trees in his small Baldwin and Roxbury Russett orchard when they were in full bloom. The very full crop which he took from the trees that year he attributes to the spraying in bloom.

Still another Orangeport grower has one Rhode Island Greening tree which was sprayed in 1899 when in full bloom. "It had twice as many perfect apples on it that year as any other Greening on the place."

Other fruit-growers in Western New York assert that they have observed an advantage from spraying at blooming time, but the experiences here given are all that were investigated. Various

fruit-growers in Western New York sprayed their apple orchards last season when the trees were in bloom, there being a strong conviction that this treatment greatly benefits the crop.

EXPERIMENTS IN THE FIELD IN 1900.

At the request of the Niagara County Farmers' Club, the Cornell Experiment Station conducted coöperative experiments with several fruit-growers in Western New York in 1900, to discover what benefit, if any, results from spraying fruit-trees when they are in full bloom. The experiments in the orchards of Harry Jackson, Medina, W. R. Mudge, Hartland, and S. S. Hopkins, North Ridge, were under the direct supervision of the Station, and all the details of spraying and record-taking were performed by an officer. The experiments in the orchards of Frank Chaplin, Gasport, Henry Bugbee, Gasport, and F. B. Freeman, Middleport, were directed by the Station, but the spraying and record-taking were done by the owners of the orchards. These men did careful work, and we have no hesitation in considering the results of their work as of equal value with our own. Their orchards were inspected. The work in all the experiments was placed in charge of S. W. Fletcher, connected with the Experiment Station, who gave the subject most careful attention. The following notes are largely his.

Unless otherwise stated, the trees in these experiments were divided into four lots: (1) Sprayed before the blossoms opened; (2) sprayed when the trees were in full bloom; (3) sprayed after the fruit had set; (4) not sprayed during the season. It was planned in the beginning to spray the third lot of trees immediately after the blossoms had fallen, but this spraying was unavoidably delayed till a week later. None of the trees used in these experiments received any spraying except what is recorded in this report. The spray used in all cases was Bordeaux mixture (mostly 4 lbs. blue vitriol and 4 lbs. lime per 50 gallons) to which was added Paris green at the rate of one-half pound to 50 gallons of Bordeaux.

Following is a sketch of the weather in Niagara and Orleans counties during the blooming season 1900:

Monday, May 13. Sunny most of the time. Very windy.

Tuesday, May 14. Partly cloudy, cool, very windy in morning. Thunder heads came up at 3 p. m., and there were heavy showers through the night.

Wednesday, May 15. Cool and cloudy in morning, becoming slightly warmer and sun came out in afternoon.

Thursday, May 16. Light showers from 6:30 to 8:30 a. m. Cleared off at 10. Sunny with cool wind in afternoon.

Friday, May 17. Cool and cloudy all day.

Saturday, May 18. Cool and cloudy in morning. Sun came out at 9:30, but cold wind during rest of the day.

Sunday, May 19. Sunny; cold northwest wind.

Monday, May 20. Opened with a slight shower at Medina, becoming sunny and a little warmer in afternoon, but wind cool.

The first three experiments were made in the orchard of Harry Jackson, Medina. This is an orchard of about twenty acres, twenty-five years old, and is mostly Baldwin and Rhode Island Greening, with a few Maiden Blush, Twenty Ounce and Spy intermingled. It was in sod and pastured with sheep until the spring of 1899, when it was plowed and then tilled once a week through the summer. Tillage was begun the past season, but was discontinued in mid-summer. The orchard was sprayed for the first time in 1899, the Kedzie mixture of white arsenic and sal-soda being used, and about six pounds of lime added to every 50 gallons of mixture. Two sprayings were given; the first before the blossoms opened, and the second when the fruit had set. The same treatment was given to all but a few trees, which were unavoidably sprayed when in full bloom. A numerous brood of canker worms was kept down that year by the arsenite. Very few were seen last season (1900). A few bud moths and case-bearers could be found in 1900, but not enough to do serious damage. All varieties except Spy have been nearly free from

scab, although no blue vitriol had been used in the orchard. The orchard has been fairly productive, but not profitably so.

Experiment 1 (Jackson).—(1) Twenty large Baldwin trees, fairly uniform in size and vigor, were selected in one row. All the trees bloomed full. The first spraying was done Monday morning, May 13, when the blossoms were just ready to burst, but none had yet opened. Sixty gallons of Bordeaux (with Paris green) were applied to five trees. Weather sunny and rather windy. (2) The second lot of trees was sprayed Monday, May 20, at 7:30 a. m., eighty gallons of Bordeaux (and poison) being used on the five trees. Fully ninety per ct. of the blossoms were open at this time. A light drizzling rain came up at 8:30 a. m., and lasted till 9:30 a. m., but not long enough to wash off much of the spraying mixture. The sun was out at 10:45 a. m. (3) The third lot of trees was sprayed Saturday, June 9, when the fruits had set, but had not yet turned down. About the same amount of Bordeaux was used as in previous sprayings. Weather partly cloudy, the sun coming out bright occasionally. (4) Five trees in the row were left unsprayed.

On June 9 and August 20, the following records were taken on these trees:

Table I.—Fruit-Setting of Baldwin Apple Trees Sprayed at Different Times.

Tree.	When sprayed.	Set of fruit, June 9.	Set of fruit, Aug. 20.
1	Before blossoms opened	Very full	Very full
2	Before blossoms opened	Very full	Very full
3	Before blossoms opened	Good	Good
4	Before blossoms opened	Good	Good
5	Before blossoms opened	Good	Good
6	In full bloom	Fair	Fair
7	In full bloom	Fair	Fair
8	In full bloom	Good	Full
9	In full bloom	Good	Fair
10	In full bloom	Good	Good
11	After fruit had set	Fair	Fair
12	After fruit had set	Light	Good
13	After fruit had set	Good	Good
14	After fruit had set	Very light	Very light
15	After fruit had set	Light	Light
16	Not sprayed	Good	Full
17	Not sprayed	Full	Good
18	Not sprayed	Good	Good
19[1]	Not sprayed	Good	Good
20	Not sprayed	Fair	Good

[1] Partly sprayed on one side by mistake.

This shows no decided gain by any treatment. Even the unsprayed trees gave good results. At picking time, In October, the difference between the crops was indistinguishable.

Experiment 2 (Jackson)—(1) The east sides of four well-grown Maiden Blush trees were sprayed on Saturday morning, May 19. About five gallons of Bordeaux were applied to each half tree. All the sides showed an abundance of bloom, and about ninety per ct. of the blossoms were open at the time of spraying. Weather cool and partly cloudy. A slight wind carried a little spray over to the west side of the trees. (2) On Saturday, June 9, when the fruit had set, the west sides of these four trees were sprayed. All of the trees had been sprayed alike with the Kedzie mixture by Mr. Jackson before the blossoms opened.

At the second spraying, June 9, and on August 20, these records were taken:

TABLE II.—FRUIT-SETTING OF MAIDEN BLUSH APPLE TREES SPRAYED IN HALVES AT DIFFERENT TIMES.

Tree	Set of fruit, June 9.		Set of fruit Aug. 20.	
	East side. (Sprayed in bloom.)	West side. (Fruit set when sprayed.)	East side. (Sprayed in bloom.)	West side. (Fruit set when sprayed.)
1	Good	Light	Full	Fair
2	Good	Good	Full	Fair
3	Full	Fair	Full	Fair
4	Good	Fair	Full	Fair

The parts sprayed in bloom gave the better results.

Experiment 3 (Jackson).—Most of the trees of Twenty Ounce in Mr. Jackson's orchard are badly attacked by apple canker. The four trees used in this experiment, although affected, are still thrifty. (1) On Saturday morning, May 19, the east sides only of these trees were sprayed at the rate of four gallons of Bordeaux to each half tree. The trees were then white with bloom. Weather cool and partly cloudy, becoming warmer in the afternoon. (2) On Saturday, June 9, when the fruit had set, the west sides of the trees were sprayed. Weather slightly cloudy.

Following are the records taken on June 9 and August 20:

TABLE III.—FRUIT-SETTING OF TWENTY OUNCE APPLE TREES SPRAYED IN HALVES AT DIFFERENT TIMES.

	Set of fruit, June 9.		Set of fruit, Aug. 20.	
Tree.	East side. (Sprayed in bloom.)	West side. (Fruit set when sprayed.)	East side. (Sprayed in bloom.)	West side. (Fruit set when sprayed.)
1	Light	Light	Good	Fair
2	Full	Light	Full	Light
3	Full	Light	Full	Light
4	Full	Light	Very full	Light

The parts sprayed when in full bloom gave the better results.

Experiment 4, in the orchard of W. S. Mudge, Hartland. This is a small orchard of about 100 trees, mostly Baldwins. It has been tilled for several years, and the trees are of good size, thrifty, and very free from insect pests and diseases. At blossoming time one had to hunt several minutes to find a bud-moth or case-bearer in this orchard. It has been sprayed for two seasons with Bordeaux mixture and Paris green. The owner states that the fruit has not been noticeably scabby or wormy in past years. In 1897, $500 worth of fruit was taken from this little orchard. One row of thirteen Baldwin trees was used in this experiment. (1) On the morning of May 15, three trees were sprayed with 45 gallons of Bordeaux. A very few blossoms were partly open on the south side of one of the trees; perhaps five per ct. of the clusters had the center blossom half open. No blossoms had opened on the other two trees. Weather sunny and windy. (2) Three more trees were sprayed with 40 gallons of Bordeaux on Friday morning, May 18, when they were in full bloom. Weather cool, partly cloudy. (3) Monday afternoon, June 11, three other trees were sprayed with 40 gallons of Bordeaux. At this time the fruit had set, but had not turned down. (4) Four trees were not sprayed.

The comparative set of fruit was estimated on June 11 and August 21:

TABLE IV.—FRUIT-SETTING OF BALDWIN APPLE TREES SPRAYED AT DIFFERENT TIMES.

Tree.	When sprayed.	Set of fruit, June 11.	Set of fruit, Aug. 21.
1	Before blossoms opened	Full	Very full
2	Before blossoms opened	Light	Fair
3	Before blossoms opened	Full	Very full
4	In full bloom	Very full	Very full
5	In full bloom	Full	Full
6	In full bloom	Full	Full
7	After fruit had been set	Fair	Fair
8	After fruit had been set	Full	Very full
9	After fruit had been set	Full	Full
10	Not sprayed	Full	Full
11	Not sprayed	Full	Full
12	Not sprayed	Full	Full
13	Not sprayed	Full	Full

No marked or constant differences, although the trees not sprayed gave rather poorer results. At picking time no constant differences could be detected.

Experiment 5, in the orchard of Frank Chaplin, Gasport. This is an orchard of about twelve acres, mostly Baldwin, set twenty years ago. It was in sod till 1895; since then it has received clean tillage. The trees are of medium size, thrifty, moderately productive in past years. Mr. Chaplin sprayed in 1899 with Bordeaux and Paris green, and again this year with the same materials. He is a very thorough sprayer. Sixteen Baldwin trees were selected, all very even in size and full of bloom. (1) Four were sprayed May 16, when a very few blossoms were partly open. Weather slightly showery in the morning, clearing off bright and cool. (2) Four other trees were sprayed Monday afternoon, May 21. The trees were then in full bloom. Weather sunny, with cool wind. (3) Tuesday morning, June 12, when the fruit had set, four more trees were sprayed. (4) Four trees were left unsprayed throughout the season.

The records taken June 12 and August 21 show no appreciable difference in fruitfulness between the four lots:

Table V.—Fruit-Setting of Baldwin Apple Trees Sprayed at Different Times.

Tree.	When sprayed.	Set of fruit, June 12.	Set of fruit, Aug. 21.
1	Before blossoms opened	Fair	Fair
2	Before blossoms opened	Light	Fair
3	Before blossoms opened	Full	Full
4	Before blossoms opened	Light	Fair
5	In full bloom	Light	Light
6	In full bloom	Full	Full
7	In full bloom	Very full	Fair
8	In full bloom	Full	Fair
9	After fruit had set	Full	Fair
10	After fruit had set	Full	Fair
11	After fruit had set	Light	Fair
12	After fruit had set	Full	Very full
13	Not sprayed	Light	Very light
14	Not sprayed	Fair	Fair
15	Not sprayed	Very full	Full
16	Not sprayed	Light	Light

No constant differences in the results. As the season advanced, the trees not sprayed showed yellower foliage and poorer fruit. At picking time, no constant differences could be determined between the lots sprayed at different times.

Experiment 6, in the orchard of Henry Bugbee, Gasport. The trees in this orchard are mostly Baldwin and Rhode Island Greening, twenty-five years set and very thrifty. The Baldwins are perhaps a little over-thrifty, and have not been as productive as they probably would have been otherwise. The orchard has been tilled for two seasons. It has not produced a good crop since 1896. Mr. Bugbee has sprayed it for six years, using Bordeaux and the Taft (arsenic) mixture in 1899, but returning to Bordeaux and Paris green this season. The trees are badly infested with bud-moth and case-bearer. The experiment in this orchard was conducted by Mr. Bugbee himself at our request. The work was done with great care. A block of ten Greenings and ten Baldwins in the northeast corner of the orchard, adjoining the orchard of Mr. Button, was set aside for the test. (1) Three trees of Baldwin and three of Greening were sprayed Wednesday morning, May 16, after the very heavy rains of the previous night. On the south and east sides of the trees, the

central blossoms of a few clusters were open. (2) Monday afternoon, May 21, three trees each of Baldwin and Greening were sprayed. These trees were then in full bloom. (3) The third lot of trees, consisting also of three Baldwins and three Greenings, was sprayed Monday afternoon, June 11. Weather clear. (4) Two trees, one each of Baldwin and Greening, were left unsprayed during the season. William Bugbee, who had charge of the spraying in his father's orchard, does a very thorough job with the spray nozzle. He plans to put eight gallons of Bordeaux on a tree. The Bordeaux and Paris green used in spraying the experimental trees was that with which Mr. Bugbee sprayed the remainder of his orchard.

The set of fruit on the trees in the experiment was estimated on June 11 and August 21 as follows:

TABLE VI.—FRUIT-SETTING OF APPLE TREES SPRAYED AT DIFFERENT TIMES.

RHODE ISLAND GREENING.

Tree.	When sprayed.	Set of fruit, June 11.	Set of fruit, Aug. 21.
1	Before blossoms opened	Fair	Fair
2	Before blossoms opened	Light	Fair
3	Before blossoms opened	Good	Fair
4	In full bloom	Light	Light
5	In full bloom	Light	Good
6	In full bloom	Light	Light
7	After fruit had set	Good	Very good
8	After fruit had set	Very light	Light
9	After fruit had set	Light	Fair
10	Not sprayed	Very full	Very full

BALDWIN.

Tree.	When sprayed.	Set of fruit, June 11.	Set of fruit, Aug. 21.
1	Before blossoms opened	Good	Full
2	Before blossoms opened	Good	Fair
3	Before blossoms opened	Very good	Fair
4	In full bloom	Fair	Light
5	In full bloom	Good	Light
6	In full bloom	Good	Fair
7	After fruit had set	Good	Fair
8	After fruit had set	Full	Good
9	After fruit had set	Light	Fair
10	Not sprayed	Fair	Fair

No constant differences are shown in these estimates.

At picking time, the orchard was again inspected, and the trees sprayed in bloom seemed to have the best fruit. Mr. Bugbee sorted and graded the apples separately from the various trees, as he would grade for market. The total crop on the experimental trees was 84 barrels. Mr. Bugbee thinks that "two conclusions may be drawn from this experiment: (1) Fruit is poorer quality when not sprayed; (2) fruit is best quality when sprayed in bloom." His figures are as follows:

Table VII.—Yield of Apple Trees Sprayed at Different Times.

Baldwins.			Greenings.		
Sprayed after fruit had set.					
*	*	*	*	*	*
4 bbls. good	5 bbls. poor	5½ bbls. average	2½ bbls. good	½ bbl. average	3½ bbls. average
Sprayed in bloom.					
*	*	*	*	*	*
4½ bbls. extra good	4½ bbls. extra good	4½ bbls. extra good	1½ bbls. extra good	4 bbls. extra good	4 bbls. extra good
Sprayed before blossoms opened.					
*	*	*	*	*	*
6 bbls. good	5 bbls. extra good	4½ bbls. extra good	4 bbls. good	4 bbls. good	4½ bbls. extra good
Not sprayed.					
*	*	*	*	*	*
		7 bbls, poor	5½ bbls. poor		

Experiment 7, in the orchard of S. S. Hopkins, North Ridge. This is an orchard of about twelve acres, all Rhode Island Greening. The trees are forty feet apart each way, and hence are not crowded like many old orchards in Western New York. Clean tillage has been given for six years. It had been sprayed with Bordeaux and Paris green for three seasons. In all particulars this is one of the best cared-for orchards in Niagara County; yet it has never borne a profitable crop, though blooming full every year. One row on the west side was set apart for the experiment. (1) Wednesday morning, May 16, when a very few

center blossoms were open on the south side of each tree, five trees were sprayed. Weather cool and cloudy at time of spraying, but sun came out bright at 10 o'clock. (2) Five more trees were sprayed Monday, May 21, when Mr. Hopkins judged them to be in full bloom. One hundred gallons of Bordeaux were used on these five trees. The weather was sunny at this spraying. (3) A third lot of five trees was sprayed Tuesday, June 12, when the fruit had set.

Notes on the setting of fruit were taken then and again August 21:

TABLE VIII.—FRUIT-SETTING OF R. I. GREENING APPLE TREES SPRAYED AT DIFFERENT TIMES.

Tree.	When sprayed.	Set of fruit, June 12.	Set of fruit, Aug. 21.
1	Before blossoms opened	Fair	Light
2	Before blossoms opened	Light	Nothing
3	Before blossoms opened	Fair	Light
4	Before blossoms opened	Full	Fair
5	Before blossoms opened	Full	Light
6	In full bloom	Full	Light
7	In full bloom	Fair	Light
8	In full bloom	Light	Light
9	In full bloom	Good	Light
10	In full bloom	Fair	Fair
11	After fruit had set	Full	Light
12	After fruit had set	Full	Very light
13	After fruit had set	Full	Light
14	After fruit had set	Full	Light
15	After fruit had set	Light	Light
16	Not sprayed	Full	Light
17	Not sprayed	Fair	Light
18	Not sprayed	Light	Light
19	Not sprayed	Fair	Light
20	Not sprayed	Light	Light

No constant difference. At picking time no differences could be detected, in quantity or quality of fruit, between any of the lots.

Experiment 8, at F. B. Freeman's, Middleport. Mr. Freeman has about twenty-five acres of bearing orchard. The one in which the experimental trees are located is in clean tillage. It has been sprayed for six years. The trees are from twenty-five to thirty years old and are of the Twenty Ounce variety. These trees have

been somewhat injured by canker. All bloomed very full during the season of 1900 when the experiment was made. Three trees were sprayed in each lot. (1) Sprayed Wednesday forenoon, May 16, with Bordeaux mixture and Paris green when the bloom had not yet fully opened. The spraying was rather light. (2) The trees sprayed when in full bloom. At harvest time it was found that the apples were fewer on the trees sprayed in bloom, but that they were larger and finer. If any conclusion is to be drawn from this experiment it seems to be that the spraying in bloom was a thinning process. Mr. Freeman writes: "My conclusions drawn from experiments last season are that the yield of both my Twenty Ounce and King sprayed in full bloom was very much diminished; in fact, was nearly a failure. What few fruits were left were fine. I had a full blossom."

THE RESULTS OF THE EXPERIMENTS OF 1900.

The experiments of 1900 neither prove nor disprove the value of spraying fruit trees when they are in bloom. In a year when sprayed and unsprayed trees alike give good crops, the results of spraying experiments are likely to be unsatisfactory. The tests must be extended over several years before it will be safe to draw definite conclusions. So far as the experiments of the past season are concerned, however, two general statements may be made:

1. In general, the trees sprayed when in full bloom bore no better crops than those sprayed either before the blossoms opened or after the fruit had set.

2. There was no apparent injury to the blossoms on trees sprayed when in full bloom.

The only exceptions to the first statement were the Maiden Blush and Twenty Ounce trees in the orchard of Harry Jackson and the results in Mr. Bugbee's orchard. The fuller set of fruit on the east sides of Mr. Jackson's trees than on the west sides was a marked difference in favor of spraying in bloom. The comparative fruitfulness of many other Maiden Blush and Twenty

Ounce trees in the orchard was observed, and no constant difference could be found. Some were more fruitful on the west side and some on the east side. It may be said that the better result from spraying in bloom was due to the fact that those trees sprayed after blooming were treated rather late; but this fault applies to all the experiments, whatever the results.

The second result (no apparent injury to blossoms) of this season's work seems to be without exception, unless in the case of Mr. Freeman's test. Trees in full bloom which were covered with Bordeaux till every flower was blue instead of white, set just as good a crop as those not sprayed in bloom. Apple blossoms on trees in Orleans County and pear blossoms on trees in the Cornell orchard were drenched with Bordeaux when fully open, and tagged. An average percentage of fruit set in both cases. Yet, despite these results, the spray may have killed many blossoms, for not one blossom in twenty could have set fruit anyway. Laboratory tests at Cornell showed that apple pollen would not germinate (or grow) after it had been immersed in Bordeaux mixture.

REMARKS ON THE ATTITUDE OF ORCHARDISTS IN THE REGION UNDER DISCUSSION.

Various apple growers of Niagara and Orleans Counties, particularly of Gasport and vicinity, contend that it is allowable or even necessary to spray when their trees are in full bloom, for three reasons:

(1) Experience is said to show that spraying when in bloom gives more and better fruit.

(2) Even as a matter of necessity and not of choice, some spraying must be done at that time. With the extent of orchards, it is sometimes impossible to complete the first spraying before blossoming time, even though the work is begun when the buds first show pink.

(3) It is doubtful whether bees are killed by arsenical sprays under normal orchard conditions.

(4) Even if arsenical sprays at blooming time do kill bees, the value of the bee interests in the orchard counties is very small as compared with the value of the fruit interests.

(5) It is not proven that bees are necessary for the fruitfulness of apples, at least of the varieties which are most grown.

The first argument of the fruit-growers is yet to be proved, but no one who has been in these great apple orchards during the blooming season can fail to feel the weight of the second point. A fruit-grower may set out to spray his twenty-acre apple orchard when the blossoms show pink, as directed in the spray calendars, but after a short "spell" of warm May weather he finds his trees in full bloom and only half of the orchard sprayed. Spring rains may prevent him from spraying till the blossoms are just ready to burst; then come two or three days of sunny weather, and his trees are in full bloom.

The third point—are bees killed by arsenical sprays at blossoming time under normal orchard conditions?—is also worthy a moment's review. The fruit men are in such overwhelming majority in the apple sections that the bee men are not often heard. In order to approach this question from the bee-keeper's point of view, three apiarists were visited and asked to give their experience and opinions on this much discussed subject. A bee-keeper of Orangeport has his hives under an apple tree which he has sprayed with arsenites when in full bloom for three years. He has not noticed more than the usual number of dead bees by the hive at this season, and the colonies have apparently done just as well as in previous years. A bee-keeper of Gasport has had the same experience. Another at Medina, who has about forty colonies, sprayed his trees with the Kedzie (arsenic) mixture last year when they were in full bloom. There was no more than the normal mortality among his bees that year. All these men believe that few, if any, bees are killed, because poisoned blossoms are distasteful to them, or else they have instinct enough to keep away. The feeling of these men on the subject is said to be shared by other bee-keepers in Western New York; but there are many who are equally certain that their colonies

would be seriously reduced in numbers if spraying at blossoming time became a common practice. The subject is still in need of careful investigation.

There have been few satisfactory experiments to determine whether bees are likely to be killed if they visit a large orchard which has been sprayed with arsenites when in full bloom. In some cases the experiment has consisted in covering the sprayed tree with sheeting or netting and placing bees inside. After awhile dead bees are found on a sheet which has been spread beneath the trees. These dead bees are then washed with ammonia water to remove any of the spraying material which might have been brushed onto their bodies. If, after this washing, the chemist finds arsenic in the bodies of these bees the conclusion is reached that they died from arsenic poisoning. These experiments merely show that if bees eat poison they will die; they do not prove that if an orchard is sprayed with an arsenite when in full bloom most of the bees visiting it will be killed.

Whether or not bees will avoid poisoned blossoms if untainted flowers are to be had is a question that fruit-growers are always asking. In 1896, Professor F. M. Webster reported three observations on this point. (1) Six apple trees were sprayed in full bloom with Paris green and water at the rate of four ounces to forty gallons. Sheets were placed under the trees and on the sheets were two hives of bees. Fifty-six dead bees were found near the hive within a week. Analysis of some of these showed traces of arsenic. (2) On the morning of a clear warm day, two apple trees were sprayed with Paris green and water at the rate of one ounce to twelve gallons. In the afternoon a number of bees which visited the blossoms were caught and marked. None of these marked bees were afterwards found dead near the hives. The next day other bees were caught, dissected and analyzed. Arsenic was found in the honey-sacs and the abdomens of some of these bees. (3) A small apple orchard was sprayed when in full bloom with Bordeaux, to which was added Paris green at the rate of four ounces per fifty gallons. Three apparently healthy colonies of bees were located on the premises. All the

bees in one colony died a few days after the application, and many in another. Arsenic was found in the bodies of the dead bees and in their dead brood. Thus bees may take the poison home and feed it to the young, killing the brood in the hive. A recent instance of great destruction of bees from spraying trees when in bloom is given by E. P. Felt, New York State Entomologist, in *Country Gentleman* for June, 1900. In some cases 80 to 95 per ct. of the working bees were killed. "The destruction was fearful, and there is every reason to think that it was due to poison thrown upon trees in blossom."

The observations of many practical orchardists seem to throw much doubt on the whole question of the relation of bees to pollination and to spraying, and seem to demand that the subject be opened for further inquiry. While working in the orchards of Orleans and Niagara counties every day for ten days during the past blossoming season, not a single bee or other insect was observed working on the blossoms. This was probably due to the cold and windy weather which prevailed during most of the blossoming season. Several fruit-growers in that section likewise reported the absence of all insect pollination in their orchards. Yet the set of fruit was the best since 1896. The wind is probably a factor in the cross-pollination of apples. If the pollen is moist or sticky, as in most varieties of pears, it is not readily blown away by the wind; hence insects are more important in the cross-pollination of this fruit. But the pollen of apple blossoms is usually nearly, or quite, dry and is probably carried by wind. But even if apple blossoms can be pollinated by wind, it may yet be true that insects are more efficient agents. Again, the varieties most commonly grown in Western New York, Baldwin and Rhode Island Greening, do not usually need cross-pollination in order to produce good crops. They are self-fertile. It was shown in Cornell Bulletin 181, however, that cross-pollination even of these varieties may be expected to give better fruit than self-pollination.

II. INVESTIGATIONS OF 1900 BY THE NEW YORK AGRICULTURAL EXPERIMENT STATION.

S. A. BEACH.

EFFECT OF SPRAY MIXTURES ON POLLEN AND ON BLOSSOMS.

The effect of spray mixture upon blossoms was studied in the laboratory and also in the orchard. Open blossoms in the orchard were sprayed and then tagged so that they might be kept under observation and the final effect of the treatment be known with certainty. In the laboratory pollen grains were put into cultures which contained neither insecticide nor fungicide and the germination and growth in these cultures were compared with the germination and growth in corresponding cultures containing either a fungicide or an insecticide or both.

LABORATORY STUDY OF THE EFFECT OF SPRAY MIXTURES UPON THE GERMINATION OF POLLEN AND THE GROWTH OF POLLEN TUBES.

In the laboratory pollen cultures were made in distilled water; in sugar solutions containing various percentages of cane sugar in water; in weak sugar solution combined with various dilutions of Bordeaux mixture made of commercial copper sulphate and lime; with Bordeaux mixture made of chemically pure ingredients; with Bordeaux mixture combined with some arsenical compound as commonly used in spraying orchards; with arsenical spray mixtures alone; and with lime alone.

Method of selecting pollen for the cultures.—The blossoms which were to furnish pollen for cultures were taken to the laboratory before they opened so as to avoid the possibility of some other kind of pollen being brought to the flower either by wind or insect. The stem which supported the blossom cluster was put into water so that the blossom buds might open. From blossoms thus treated a single anther was selected to furnish pollen for all of the cultures in a series. It is believed that by this method pollen of as uniform vigor as it was possible to obtain was furnished for all cultures which were to be compared in a single series.

The cultures.—Hanging drop cultures were made in Van Tieghem cells 10 to 12 mm. inside diameter and about 10 mm. high sealed with a mixture of wax and vaseline. The pollen was placed on a clean cover glass, a drop of the culture liquid was applied and some of the same was put into the bottom of the cell so that the liquid in the cell would be of the same composition as that in the drop. The cover glass was then put into its place and sealed.

POLLEN CULTURES IN MIXTURE A.

A spray mixture which for convenience of reference is here called "A" was made from the ordinary commercial materials. It consisted of Bordeaux mixture prepared as is usually done for spraying orchards. This was made according to the 1-to-11 formula.[1] An arsenical poison, the green arsenite of copper, was then added at the rate of about 1 lb. to 150 gallons, the amount commonly recommended for spraying orchards. Mr. W. H. Andrews very kindly analyzed this green arsenite and found 57.5 per ct. arsenious oxide and 25.2 per ct. copper oxide. This shows that as an insecticide it is equivalent to good Paris green.

An anther from a Ben Davis apple blossom was selected May 18 in the way already described. From the pollen which it furnished a series of cultures was made as recorded below. This is here called Series I.

SERIES I.

Culture No.	Medium.	Number of pollen grains in the culture.
9	2 per ct. aqueous cane sugar solution, 99 parts; mixture A, 1 part	250 to 300
10	2 per ct. aqueous cane sugar solution, 99½ parts; mixture A, ½ part	125 to 150
11	2 per ct. aqueous cane sugar solution, 99.98 parts; mixture A, .02 part	125 to 150
12	2 per ct. aqueous cane sugar solution, 99.99 parts; mixture A, .01 part	100 to 125

As soon as these cultures were made, 5.45 p. m., they were put into a room having a nearly constant temperature of about

[1]This formula requires 1 lb. of copper sulphate, and the necessary amount of lime, in making 11 gallons of the mixture. It is equivalent to 10.9 grams of copper sulphate for 1 litre of the mixture.

70° F. or slightly more. At 9.30 a. m. of the following day perhaps half of the grains in No. 9 had germinated but they showed decidedly the retarding effect of the poisons. In No. 10 the germination and growth were no better than in No. 9, really not quite so good. In No. 11 the grains germinated freely; nearly or quite all of them had germinated and the tubes had made free growth. In No. 12 germination and growth had progressed as freely as in No. 11.

At 5.20 p. m. of the same day, about 24 hours after the cultures had been started, these notes were made.

No. 9. Pollen tubes vary from 1.96μ to 18.48μ long: average length perhaps 10μ. Many tubes which were apparently in perfect condition this morning have now broken down and become disintegrated. Many of the pollen grains have not yet germinated.

No. 10. Pollen tubes vary from 1.68μ to 14μ long. They average perhaps 7μ. Some of the pollen tubes have become disintegrated like those noted in No. 9.

No. 11. The pollen tubes have made good growth. They vary in length from 10.67μ to 87.36μ and average perhaps from 60μ to 75μ. Occasionally tubes are seen which are abnormally swollen and give some appearance of breaking down.

No. 12. The pollen tubes have made good growth. The tubes vary in length from 8.4μ to 75.6μ or more. No disintegration of pollen tubes was noticed.

At 5 p. m., May 22, four days after these cultures were made, the following notes were taken and the cultures were then discarded.

No. 9. It is estimated that from 30 per ct. to 50 per ct. of the pollen grains in this culture have germinated. One of the longest tubes measured 51.96μ, but such length was quite exceptional. Most of the tubes were less than one-half or even one-third of that length; many were no longer than from 5μ to 10μ The tubes are apt to be abnormally curved or twisted and the growth is not vigorous. Indeed there is an appearance of disintegration of some of the tubes.

No. 10. It is estimated that no more than 25 per ct. have germinated. The growth is correspondingly less than in No. 9. One of the longest tubes measured 27μ. The tubes probably do not average half that length. Oftentimes they are abnormally bent and in many cases disintegration is seen.

No. 11. This culture shows a network of long tubes. One which was measured was 93.4μ long, but it cannot be said that this is one of the longest of them. Only in a few cases can tubes be traced through their entire length because they are so much tangled, and a close estimate of their average length cannot be made. It may be said, however, that they have made abundant growth.

No. 12. Pollen tubes are tangled so much that only in few instances can they be traced throughout their entire length. One measured 52.56μ, but others were certainly longer. The average length is estimated as considerably less than in No. 11. Only occasional indications of disintegration were seen.

POLLEN CULTURES IN MIXTURE B.

The spray mixture which is here designated "mixture B" was simply a Bordeaux mixture made as for "mixture A," but it did not have any arsenical poison added to it. A single anther from a Ben Davis apple blossom was selected May 17 in the way previously described, p. 374, to furnish pollen for a series of tests in which the growth of pollen in solution of sugar in water might be compared with its growth in a similar sugar solution combined with various proportions of the Bordeaux mixture B. The following cultures were made at 5 p. m., May 17. They were put into a room in which by means of an automatic apparatus the temperature was kept nearly constant at about 70° F. to 72° F.

SERIES II.

Culture No.	Medium.	Number of pollen grains in the culture.
4	2 per ct. aqueous solution cane sugar	Several hundred
5	5 per ct. aqueous solution cane sugar	Not recorded
6	10 per ct. aqueous solution cane sugar	About 250
7	5 per ct. aqueous solution cane sugar, 95 parts; Bordeaux mixture B, 5 parts	About 300
8	2 per ct. aqueous solution cane sugar, 98 parts; Bordeaux mixture B, 2 parts	Several hundred

May 18, at 10.30 a. m., the following notes were made on these cultures.

No. 4. Nearly every grain has germinated and sent out a vigorous pollen tube. The tubes vary in length from about 15 to 130μ or more. The growth is so much tangled that it is impossible to measure each tube. The average length may be estimated at about 80μ.

No. 5. The percentage of germination is almost as high as in No. 4. The tubes vary in length from 9.5μ to 175μ or more. The growth is matted as noted under No. 4 so that it is impossible to get the exact measurement of each tube.

No. 6. It appears that 50 per ct. of the pollen grains have germinated, but the average length of the tubes is much shorter than either those of No. 4 or No. 5. The tubes vary from about 7μ to about 86μ or possibly more.

No. 7. None has germinated.

No. 8. None has germinated.

At 6 p. m. the same date neither 7 nor 8 had yet shown any germination. The condition of Nos. 4, 5 and 6 was relatively about the same as when the last observation was made. This series of cultures was discarded at 4:40 p. m., May 22. At that time 50 per ct. of the pollen grains had germinated in No. 6, the 10 per ct. sugar solution. In No. 7, which contained 5 per ct. Bordeaux mixture B and 5 per ct. sugar solution no germination was found. But in No. 8, which contained 2 per ct. Bordeaux mixture B and 2 per ct. sugar solution a single pollen tube was found. This was 3.36μ long. One other pollen grain had the appearance of having sent out a tube of about the same length which had disintegrated before it was observed. The other cultures, 4 and 5, so far as could be determined retained about the same relative rank as to growth as was noted before, but the growth was too abundant and the tubes too much matted together to make definite conclusion on this point. It was noticed, however, that some pollen grains in 5 had not yet germinated.

POLLEN CULTURES IN MIXTURE C.

The mixture which for convenience of reference is here called C consisted of a Bordeaux mixture made wholly of chemically pure ingredients combined with a solution of cane sugar in water. The formula used was 1 gram of copper sulphate and $\frac{3}{4}$ gram of lime to make 100 cc. Bordeaux mixture.[1] After the copper sulphate solution and lime had been combined and diluted to 96 cc. with distilled water 4 cc. of 50 per ct. aqueous cane sugar solution were added to bring the whole mixture up to 100 cc. Work with mixture C did not begin until after apples were out of bloom and so the results given with it were obtained with other kinds of pollen than that used for the cultures in mixtures A and B.

Van Tieghem cell cultures which were made in the way previously described, p. 375, were prepared June 28. In each one was put some blackberry pollen from the same anther. The following statement shows the medium used for each culture.

SERIES III.

Culture No.	Medium.	Number of pollen grains in culture.
15	Mixture C, 100 parts	128
16	Mixture C, 2 parts; 2 per ct. aqueous solution of cane sugar, 98 parts	115
17	Mixture C, 1 part; 2 per ct. aqueous solution of cane sugar, 99 parts	108
18	Mixture C, ½ part; 2 per ct. aqueous solution of cane sugar, 99½ parts	64
19	Mixture C, $\frac{1}{50}$ part; 2 per ct. aqueous solution of cane sugar, 99 $\frac{49}{50}$ parts	43
20	Copper arsenite and lime, 1 gram to 1¼ liters; in 2 per ct. aqueous solution[2] of cane sugar	About 12
21	Lime, 1 gram to 1.25 liters of a 2 per ct. aqueous solution[3] of cane sugar	69
22	Cane sugar, 2 per ct. aqueous solution	107

[1]This is the same as 10 grams copper sulphate to make 1 liter of Bordeaux mixture which formula is nearly equivalent to the 1-to-11 formula. See p. 375.

[2]This is at the rate of about 1 lb. to 150 gallons.

[3]The copper arsenite, $CuHAsO_3$, was used at the rate of 1 gram to 1.25 liters. This is approximately the strength at which either this or Paris green is used in orchard spraying; i. e., about 1 lb. to 150 gallons. Lime was added at the same rate as the copper arsenite; i. e., 1 gram to 1.25 liters, and cane sugar solution at a rate to make the whole a 2 per ct. solution of cane sugar.

When preparation of these cultures was finished, at 5 p. m., June 28, they were put into moist chambers and kept in a room having nearly constant temperature of about 70° to 72° F. When they were examined at 8.40 a. m., June 29, no pollen had germinated in any of them except in No. 22 which contained 2 per ct. sugar solution in water only. In this culture out of 107 pollen grains 9, or about 8 per ct., had germinated.

The cultures were kept four days, till July 2, and then discarded. During this time they were kept in the room above mentioned except that on one day, June 29, they were for about ten hours in a room where the temperature ranged from 80° F. to 82° F. On July 2 the following notes were made:

No. 15 shows no germination.
No. 16 ditto.
No. 17 ditto.
No. 18. ditto.
No. 19. Twelve pollen grains, or 28 per ct., show evidence of germination. In these cases the germ tube has only attained a length of from one-half to two-thirds the diameter of the pollen grain and then disintegration has followed.
No. 20 shows no germination.
No. 21 destroyed by accident.
No. 22 shows 52 germinations or 49 per ct.

About 11.30 a. m., June 19, the following cultures were made with rose pollen.

SERIES IV.

Culture No.	Medium.	Number of pollen grains in culture.
30	Mixture C, 1 part; aqueous solution of cane sugar, 99 parts	About 150
31	Cane sugar, 2 parts; water, 98 parts	About 150

These cultures were kept in moist chambers in the laboratory till 5.30 p. m., or 6 hours. There were then no germinations in No. 30, but 36 pollen grains out of about 150 in culture No. 31 had already germinated. The cultures were then kept in the

room having a temperature of 70° F. On July 2, after being kept three days many more germinations were found in No. 21 but none in No. 30.

Cultures of pollen of the Virginia Creeper, *Ampelopsis quinquefolia*, all from the same anther, were made at 11:30 A. M., July 25, 1900, as listed below.

Series V.

Culture No.	Medium.	Number of pollen grains in culture.	Number germinated.	Per ct. of germination.
35	2 per ct. aqueous cane sugar solution, 2 parts; water, 98 parts	88	66	75
36	Lime, 1 gram to 125 cc. of a 2 per ct. aqueous solution of cane sugar	144	0	0
37	Copper arsenite and lime[1] and a 2 per ct. aqueous solution cane sugar	230	0	0
38	Mixture C, 1/50 part; aqueous solution of cane sugar 99 49/50 parts	203	136	67
39	Mixture C, ½ part; aqueous solution of cane sugar, 99½ parts	118	5	4
40	Mixture C, 1 part; aqueous solution of cane sugar, 1 part	187	0	0
41	Mixture C, 2 parts; aqueous solution of cane sugar, 98 parts	122	0	0

After six hours it was found that many pollen grains had germinated in Nos. 35 and 38. Five had also germinated in No. 39. There were no germinations in any of the other cultures. At 8:30 A. M., July 26, after the cultures had been made 21 hours it was found that there were 66 germinations in No. 35, or 75 per ct.; in No. 38 there were 136 or 67 per ct.; and in No. 39 there were 5, or 4 per ct. In none of the other cultures was any germination found. After being kept 24 hours longer no further germination was found and these cultures were discarded.

Cultures of the pollen of Japan ivy, or Boston ivy, *Ampelopsis tricuspidata*, were made at 11:30 A. M., July 30, using the same media as in Nos. 37 to 41, and also one culture was made in a 2 per ct. sugar solution in water alone.

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[1]Prepared as for culture No. 20, see p. 379.

SERIES VI.

Culture No.	Medium.	Number of pollen grains in culture.	Number of germinations.	Per ct. of germination.
56	2 per ct. aqueous solution cane sugar..	119	90	76
57	Copper arsenite and lime[1] and a 2 per ct. aqueous solution cane sugar......	161	0	0
58	Mixture C, $\frac{1}{50}$ part; 2 per ct. aqueous solution cane sugar $99\frac{49}{50}$ parts........	15	14	93
59	Mixture C, 1 part; 2 per ct. aqueous solution cane sugar 99 parts[2].........			
61	Mixture C, 2 parts; 2 per ct. aqueous solution cane sugar 98 parts.........	about 300	0	0

The cultures were kept in a moist chamber in a room at about 81° F. till 2:45 P. M., of July 30, or about $3\frac{1}{4}$ hours. It was then found that 76 per ct. in the culture No. 56 had germinated and 93 per ct. in No. 58. No germination was found in any of the other cultures.

Twenty-one hours after the cultures were made they were discarded because no further germination took place.

SUMMARY OF RESULTS WITH POLLEN CULTURES.

In the cultures with apple pollen in cane sugar solutions in water alone (see Series II) the pollen tubes seemed to do better in a 2 per ct. solution than in either a 5 per ct. or a 10 per ct. solution. They also grew better in the 2 per ct. sugar solution in water than in pure water. For these reasons the media for the cultures in Series I, III, IV, V and VI were made to contain a 2 per ct. aqueous solution of cane sugar.

Series I.—Culture media contained cane sugar solution in water, Bordeaux mixture and green arsenite of copper.—In this series pollen from Ben Davis apple was used. Only from one-third to one-half of the pollen grains germinated in the 1 per ct. mixture A, culture 9, which contained but 100 parts in 10,000 of an ordinary mixture used in spraying orchards, the remaining 9,900 parts being a weak solution of cane sugar in water. The tubes from the pollen which did germinate grew slowly and were dwarfed and abnormal in shape.

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[1]Prepared as for cultures No. 20, see p. 379.

[2]Destroyed by accident before last examination was made.

In culture 10 which contained but 50 parts of the spray mixture in 10,000, no more than one-quarter of the pollen germinated, and that made even less vigorous growth than was made in culture 9.

In culture 11 which contained but 2 parts of the spray mixture in 10,000, and in culture 12 which contained but 1 part in 10,000, the germination of the pollen and growth of pollen tubes progressed freely.

Series II.—Culture media contained cane sugar solution in water and Bordeaux mixture.—In the 2 per ct. aqueous solution of cane sugar alone the pollen from Ben Davis apple germinated freely and the growth was vigorous and abundant. When 200 parts in 10,000 of ordinary Bordeaux mixture were combined with this sugar solution, culture 8, germination was almost wholly stopped. But two pollen tubes started to grow and one of these soon became disintegrated. When 500 parts Bordeaux mixture in 10,000 were used with a stronger (5 per ct.) sugar solution in water no germination took place.

Series III.—Culture media contained cane sugar solution in water combined with Bordeaux mixture made from chemically pure ingredients; also with lime alone and with lime and green arsenite of copper.—In this series blackberry pollen was used. Even in the dilute sugar solution alone hardly half of the pollen grew. Bordeaux mixture of the strength commonly used in spraying orchards, mixture C, was used at full strength and also was diluted with the weak sugar solution till it formed in the different cultures respectfully 200 parts, 100 parts, 50 parts and 2 parts in 10,000. In none of these media except the last named did germination take place, in which case 28 per ct. of the pollen grains in the culture started to germinate but before further growth took place disintegration followed. It appears that the blackberry pollen is even more sensitive to the poisons commonly used in making spray mixtures than is apple pollen. The copper arsenite and lime when not combined with Bordeaux mixture prevented germination of the pollen. Even the lime alone seemed

to have the same effect, but only one incomplete test was made with this material in this series.

See also Series V.

Series IV.—Bordeaux mixture made as in Series III compared with an aqueous solution of sugar cane alone.—Bordeaux mixture made as for Series III and diluted to 100 parts in 10,000 of the 2 per ct. aqueous sugar solution wholly prevented the germination of rose pollen in culture 30 while in the corresponding culture containing the sugar solution alone there were many germinations.

Series V.—Culture media as in Series III.—The media used in Series III when tested on pollen of Virginia creeper, *Ampelopsis quinquefolia*, showed a like effect in kind only to a slightly less degree than with the blackberry pollen. In the cane sugar solution in water alone 75 per ct. of the pollen germinated; in the aqueous solution of cane sugar with 2 parts in 10,000 of the Bordeaux mixture C added, 67 per ct. germinated; with 50 parts in 10,000 added, 4 per ct. germinated; with 100 parts and with 200 parts in 10,000 added there was no germination. The copper arsenite and lime in culture 37 prevented germination as did also lime alone in culture 36.

Series VI.—Culture media of this Series duplicate those used in Series III except culture 21.—Pollen of Japan ivy *Ampelopsis tricuspidata*, tested in the media used in Series III and V showed 76 per ct. germination in the cane sugar solution alone; 93 per ct.[1] in the medium containing two parts of Bordeaux mixture C in 10,000; no germination took place in the media containing respectively 50 parts, 100 parts and 200 parts of the Bordeaux mixture C in 10,000. In the medium containing copper arsenite and lime there was no germination.

From these investigations it appears that if before pollination occurs the stigmatic surface of the pistil should be covered either

[1]This culture contained but 15 pollen grains while the cane sugar solution just mentioned contained 119 pollen grains. Judging from general experience with these cultures it seems quite probable that had the former culture contained an equal number of pollen grains the percentage of germination would have been no higher than it was in the latter culture.

with Bordeaux mixture alone or with arsenical poison alone of the strength commonly used in spraying orchards there would be no germination of any pollen which might afterwards reach the stigmatic surface and so fertilization would be prevented and no fruit would be formed. Even the presence of lime alone, of the strength commonly used in spray mixtures, prevented the germination of pollen. Bordeaux mixture was diluted in aqueous sugar solution to 500 parts, 200 parts, 100 parts, 50 parts, 2 parts and 1 part in 10,000 of culture media into which various kinds of pollen were introduced. Even when diluted to 50 parts in 10,000 it prevented germination to large extent and where germination did occur the growth which followed was decidedly slow and the pollen tubes were dwarfed. When diluted to 100 parts, 200 parts or 500 parts either no germination or practically none was found.

Effect of Spray Mixtures on Apple Blossoms.

In order to test the practical effect of the spray upon open apple blossoms the following tests were made.

Individual blossoms known to have been hit by spray mixtures.—Blossoms of Hurlbut and Jefferies were sprayed soon after they opened. On the other hand Baldwin and R. I. Greening were sprayed several days after the trees commenced to bloom. It is instructive to note the different results obtained. On a Hurlbut tree which was chosen for one of the tests the blossoms commenced to open May 13. Open blossoms on one side of the tree were sprayed the next day with Bordeaux mixture, 1-to-11 formula, combined with green arsenite of copper, 1 lb. to 150 gallons. At that time one could rarely find an anther which had begun to discharge its pollen[1]. Some of the sprayed blossoms were examined and those which plainly showed the spray mixture in the center were tagged. In case the spray could be clearly seen on the stigmatic surface the tag was given a special mark to dis-

[1]The structure of the apple blossom is explained and its parts are named on p. 395.

tinguish it. On another part of the tree some open blossoms which had not been sprayed were tagged for comparison with the sprayed blossoms.

A Jefferies apple tree which showed its first bloom May 13, also had a part of its blossoms sprayed May 14. They were marked after the same plan which was followed with the Hurlbut and unsprayed blossoms were likewise tagged for comparison.

Later observations showed that out of 42 sprayed Hurlbut blossoms which were known to have been hit by the spray 36, or 86 per ct., failed to set fruit, while out of 31 corresponding blossoms which were not sprayed only 5, or but 16 per ct. failed to set fruit. Out of 11 Jefferies blossoms known to have been hit by the spray 8, or 73 per ct. set no fruit while out of 10 corresponding unsprayed blossoms only 3, or 30 per ct., failed to set fruit. None of the blossoms which were seen with spray mixture on the stigmatic surface of the pistils set fruit on either tree.

The Baldwin and R. I. Greening trees which were used in this test were sprayed a week later, on May 21, using the same kind of spray mixture as before. It was difficult at this time to find branches of the tree which were, properly speaking, in full bloom because in so many cases the center flower of the cluster had already gone out of bloom. The center blossom of the cluster opens first and naturally may be expected to drop its petals before the other flowers of the cluster do. Some branches were finally found on the northeast side of the tree on which most of the clusters were still, strictly speaking, in full bloom, although, in the blossoms on two of the trees as the sequel shows, the pollen tubes had doubtless in the majority of cases already entered the style and passed beyond the reach of the poisonous influence of the spray mixture. After they had been sprayed some of the blossoms were examined and tagged in the way already described for the Hurlbut blossoms. Corresponding unsprayed blossoms were likewise labeled. Later observations showed that none of of the blossoms which had the stigmatic surfaces plainly covered by the spray mixture set fruit. Out of 45 R. I. Greening blossoms

on one tree which were known to have been hit by the spray 39, or 87 per ct., set no fruit. Out of 49 corresponding blossoms which were not sprayed 26, or 53 per ct., did not set fruit. In this case probably the blossoms had not been open so long as in the following two cases.

On another R. I. Greening tree 48 blossoms were marked as hit by the spray of which but 3, or 6 per ct., failed to set fruit while 25 out of 50 blossoms which were not sprayed, or 50 per ct., did not set fruit.

On a Baldwin tree 50 blossoms were marked as hit by the spray, of which 31, or 62 per ct., failed to set fruit while 32 out of 47 unsprayed blossoms, or 68 per ct., set no fruit.

In the tests with the Hurlbut and Jefferies and in one test with R. I. Greening the sprayed blossoms were nearly always ruined by the treatment. In one test with R. I. Greening and in the test with Baldwin the treatment reduced the percentage of fruit which set but little if any below the percentage which set on unsprayed portions of the tree. These experiments suggest the idea that if the apple trees are not sprayed until after the most of the blossoms have been open for several days the treatment will not interfere to any considerable extent with the setting of the fruit, but further experiments are required to demonstrate whether or not this idea is correct.

The processes of the opening of the blossoms and of the anthers, the germination of pollen and the growth of pollen tubes are hastened by the higher and retarded by the lower temperatures. It cannot be stated definitely how long a time is required after the blossom opens for the pollen to reach the stigma, to germinate and to send the pollen tube into the style far enough for it to be beyond the reach of the toxic effect of spray mixtures applied to the open blossoms. It is desirable that this subject be thoroughly investigated in order that the fruit growers may understand when the blossoms have developed enough to be out of danger of being ruined by spray mixtures.

Apple trees sprayed repeatedly while in bloom.—Some tests were made in the orchards at the Experiment Station in which apple

trees were sprayed repeatedly while they were in bloom for the purpose of hitting so far as possible the blossoms as they opened from day to day. The treatments began with the first blossoms which opened and continued till the last ones appeared. The spray mixture used was Bordeaux mixture, 1-to-11 formula, combined with green arsenite of copper, 1 pound to 150 gallons.

A McIntosh apple tree which had been topworked to this variety 13 years ago, was selected for one of the tests. It was not so high as to prevent the thorough spraying of all parts. It had an abundance of blossom buds which were quite evenly distributed over the tree. Two limbs on the east side were sprayed and the rest of the tree was left unsprayed. The number of treatments is stated below.

McINTOSH SPRAYED REPEATEDLY WHILE IN BLOOM.

Date of Treatment.	Condition of Bloom.
May 15..	First blossoms are now open.
May 16..	More than 75 per ct. of the clusters have all of the buds now open.
May 17..	From 75 per ct. to 90 per ct. of all blossoms are now open.
May 19..	Petals of first blossoms are failing. All other blossoms are practically now in full bloom.
May 21..	A few clusters have one or two blossoms with petals still attached to them. Probably 95 per ct. of all of the blossoms have passed out of bloom.
May 22..	Tree almost entirely out of bloom.
May 23..	Tree entirely out of bloom. Spraying now discontinued.

Ten days after this tree went out of bloom, before the first dropping of young fruits had begun to any appreciable extent, small branches which appeared to represent fairly the condition of the sprayed side of the tree were compared with corresponding branches from the unsprayed side of the tree. Every cluster was examined to see whether any fruit had set. The following table shows the number of clusters which set fruit, and the whole number of fruits which set on typical branches sprayed repeatedly in bloom compared with the numbers on typical branches which were not sprayed in bloom.

TABLE IX.—FRUIT-SETTING ON TYPICAL BRANCHES OF MCINTOSH.

	Sprayed repeatedly in bloom.		Not sprayed in bloom.	
	No	Per ct.	No.	Per ct.
Whole number of clusters examined	132		143	
Clusters which set no fruit	108	82	2	1
Clusters which set 1 fruit	18	14	37	26
Clusters which set 2 fruits	6	4	47	33
Clusters which set 3 fruits	0	0	44	31
Clusters which set 4 fruits	0	0	11	8
Clusters which set 5 fruits	0	0	2	1
Average number of fruits per 100 clusters on June 2	23		221	

It was intended that the yield of ripe fruit from branches sprayed in bloom should be compared with that from the corresponding branches which were not so treated. Towards the close of the season there was but very little fruit on the branches which were sprayed in bloom while on the other branches there remained a fairly good crop of fruit. The severe wind storm of September 11 and 12 blew off nearly all of the fruit and the windfalls of one side of the tree could not be separated from those of the other side so that the final record of the yield could not be taken.

An apple tree of Reinette de Caux which had been top-worked to this variety eighteen years ago was treated according to the plan stated above. Its height was about the same as that of the McIntosh tree. Its blossom buds were extremely abundant and uniformly distributed. One-half of the tree was sprayed in bloom on the dates given below. The opposite side was left unsprayed during the blooming season.

REINETTE DE CAUX SPRAYED REPEATEDLY WHILE IN BLOOM.

Date of Treatment.	Condition of Bloom.
May 15....	First blossoms opening.
May 16....	Some clusters have from one-third to one-half of their blossoms open. About 40 per ct. of all blossoms are now open.
May 17....	Probably from 60 per ct. to 75 per ct. of blossoms are now open.
May 19....	Tree is practically in full bloom. The petals of the first blossoms to open are not yet falling.

Date of Treatment.	Condition of Bloom.
May 21....	Probably one-third of the blossoms have already dropped their petals.
May 22....	Petals rapidly falling.
May 23....	Ditto.
May 24....	Probably 95 per ct. of the blossoms have dropped their petals.
May 25....	Tree is practically out of bloom. Perhaps a dozen blossoms are still in bloom.
May 26....	An occasional blossom may still be seen. No spraying of this tree in bloom was made after this date.

On June 2 typical branches were selected and a record was made of the number of fruits which were found in the same way as was done with the McIntosh tree. The results are summarized in the following statement of the number of fruits which set on typical branches sprayed repeatedly in bloom compared with the number which set on typical branches which were not sprayed in bloom.

TABLE X.—FRUIT-SETTING ON TYPICAL BRANCHES OF REINETTE DE CAUX.

	Sprayed repeatedly in bloom.		Not sprayed in bloom.	
	No.	Per ct.	No.	Per ct.
Whole number of clusters examined...........	217		169	
Clusters which set no fruit....................	207	95	9	5
Clusters which set 1 fruit......................	8	4	24	14
Clusters which set 2 fruits.....................	2	1	61	37
Clusters which set 3 fruits.....................	0	0	53	31
Clusters which set 4 fruits.....................	0	0	18	11
Clusters which set 5 fruits.....................	0	0	4	2
Average number of fruits per 100 clusters on June 2..................................	6		235	

The record of the yield of ripe fruit for the treated and untreated sides of this tree cannot be given because the windstorm of September 11 and 12 mingled the wind falls from the different branches so that no accurate separate records could be made. All through the season this tree furnished a most striking object lesson of the effect which spraying in bloom may have upon the yield of fruit. The half of the tree which was sprayed repeatedly during the blooming season ripened prob-

ably less than a peck of fruit. The opposite side which was not sprayed in bloom bore a very heavy crop; so heavy, in fact, that the windstorm referred to broke down the limbs on that side and ruined the tree.

A Fall Pippin apple tree was selected for a similar test and a corresponding tree of the same kind which appeared to have about the same amount of blossom buds, was chosen for comparison. These trees were 50 years old. The top branches could not be reached with the spray well enough to insure thorough application to the blossom clusters, accordingly only the lower parts of the tree which could be readily reached with the extension rods used in applying the spray, were included in the test. The dates on which the treatments were made appear in the following statement.

Fall Pippin Sprayed Repeatedly While in Bloom.

Date of treatment.	Condition of bloom.
May 16....	About 12 per ct. of the blossom buds are now open. None but the center blossoms have yet opened.
May 17....	None but center blossoms have yet opened and not all of these are open.
May 19....	Rain yesterday prevented spraying. Perhaps 20 per ct. to 25 per ct. of all blossom buds are now open.
May 21....	Probably 75 per ct. of blossom buds have opened. But few clusters have all blossoms open.
May 22....	
May 23....	
May 24....	The petals have fallen from about one-half of the blossoms.
May 25....	The petals have fallen from about three-fourths of the blossoms.
May 26....	
May 27....	The petals have fallen from perhaps 90 per ct. to 95 per ct. of the blossoms. No further spraying in bloom was done to this tree.

On June 4, typical branches from this tree and from the corresponding tree which was not sprayed in bloom were compared, and the following records of the fruits which were found were taken in the way described above for McIntosh. Plate LVI, Fig. 1, shows a cluster of Fall Pippin sprayed in bloom while a corresponding cluster from the Fall Pippin which was not

sprayed in bloom is shown in Fig. 2. The following table shows the number of fruits which set on typical branches sprayed repeatedly in bloom compared with typical branches not sprayed in bloom.

TABLE XI.—FRUIT-SETTING ON TYPICAL BRANCHES OF FALL PIPPIN.

	Sprayed repeatedly in bloom.		Not sprayed in bloom.	
	No	Per ct.	No.	Per ct.
Whole number of clusters examined....	235		218	
Clusters which set no fruit............	222	94	12	6
Clusters which set 1 fruit..............	9	4	68	31
Clusters which set 2 fruits............	0	0	79	36
Clusters which set 3 fruits............	3	1½	41	19
Clusters which set 4 fruits............	1	½	17	7½
Clusters which set 5 fruits............	0	0	1	½
Average number of fruits per 100 clusters on June 4....................	9		180	

Apple trees sprayed but once while in bloom.—In the tests which have just been considered an effort was made to hit with the spray each blossom soon after it opened. For this reason the treatments were given at intervals of from one to two days during the entire blooming season. Tests were also made in four other apple orchards in which the treated trees were sprayed but once while in bloom. General observation in these orchards confirmed the conclusion that spraying the open blossoms often prevents their further development. Particular observations were made on two varieties which had been sprayed once in bloom. These were Pumpkin Sweet, commonly called *Pound Sweet*, and Baldwin located in the orchard of J. B. Collamer & Son, Hilton, N. Y. These observations were taken in the way already described for McIntosh, p. 388. It is interesting to compare the results, as given below, with those obtained with trees which were sprayed repeatedly during the blooming season.

Observations made June 5 on branches of a Baldwin tree which was sprayed in full bloom on May 23, and of a corresponding Baldwin tree which was not given this treatment show results for typical branches given in the table below.

PLATE LVI.—FLOWER CLUSTERS FROM FALL PIPPIN APPLE TREE: 1, SPRAYED IN BLOOM—ALL BLOSSOMS DEAD; 2, NOT SPRAYED IN BLOOM—AT LEAST FOUR FRUITS SET. (Clusters Photographed on Same Day.)

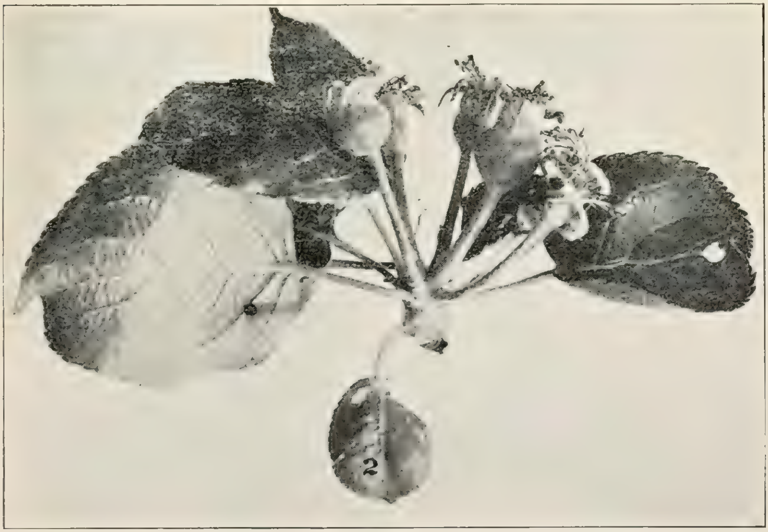

Plate LVII.—Flower Clusters from Baldwin Apple Tree: 1, Sprayed Once in Bloom—all Blossoms Dead, with Possibly One Exception; 2, Not Sprayed in Bloom—at Least Two Vigorous Fruits Set.

(Clusters Photographed on Same Day.)

PLATE LVIII.—FLOWER CLUSTERS FROM TWENTY OUNCE APPLE TREE: 1, SPRAYED ONCE IN BLOOM—CENTER BLOSSOM DEAD, BUT LATER SIDE BLOSSOMS HAVE SET SOME FRUIT; 2, ANOTHER TREE SPRAYED IN BLOOM—ALL BLOSSOMS DEAD.

(Clusters Photographed on Same Day.)

Table XII.—Fruit-Setting on Typical Branches of Baldwin.

	Sprayed once in bloom.		Not sprayed in bloom.	
	No.	Per ct.	No.	Per ct.
Whole number of clusters examined....	81		49	
Clusters which set no fruit..............	34	42	5	10
Clusters which set 1 fruit..............	37	46	15	31
Clusters which set 2 fruits.............	8	10	17	35
Clusters which set 3 fruits.............	2	2	11	22
Clusters which set 4 fruits.............	0	0	1	2
Average number of fruits per 100 clusters on June 5....................	73		176	

This statement shows clearly that even spraying once in bloom may lessen very much the proportion of fruit which sets. Fig. 1, Plate LVII, shows a cluster from the Baldwin tree which was sprayed in bloom, as it appeared June 5. This illustrates the kind of injury which may follow the spraying of trees when in bloom. None of these blossoms have set fruit except possibly one of the latest on the outside of the cluster which seems to have swollen somewhat and might have developed into fruit. Fig. 3, Plate LVII, shows a cluster which was taken on the same day from the corresponding tree not sprayed in bloom. This shows how abundantly the fruit set on these Baldwin trees where the blossoms were not hit by the spray.

Plate LVIII, Fig. 1, shows a cluster from a Twenty Ounce tree sprayed once in bloom. The treatment killed the central blossom but the later outside blossoms set some fruit. Fig. 2 shows another cluster of the same variety in which none of the blossoms survived the treatment. The table shows the number of fruits which set on typical branches sprayed but once in bloom compared with the number which set on typical branches not sprayed in bloom.

Table XIII.—Fruit-Setting on Typical Branches of Pumpkin Sweet.

	Sprayed once in bloom.		Not sprayed in bloom.	
	No.	Per ct.	No.	Per ct.
Whole number of clusters examined....	95		100	
Clusters which set no fruit..............	82	86	74	74
Clusters which set 1 fruit...............	13	14	20	20
Clusters which set 2 fruits..............	0	0	5	5
Clusters which set 3 fruits..............	0	0	1	1
Average number of fruits per 100 clusters on June 5....................	14		33	

There was very little fruit produced on any of the Pumpkin Sweet trees whether they were sprayed in bloom or not. The Baldwins produced considerable fruit, but not a good crop.

SUMMARY OF RESULTS OF THE TESTS OF THE EFFECT OF SPRAY MIXTURES ON APPLE BLOSSOMS.

In the orchards where trees were sprayed in bloom general observation at the blooming season and at various later periods till the fruits were as large as cherries, and a comparison of trees so treated with corresponding trees which were not sprayed in bloom, forced the conclusion that much fruit was destroyed by the treatment. That the yield of the treated trees was not more seriously diminished may be accounted for by the very great abundance of the blossoms and by the fact that at no one time were all of them open and in that stage when they are most susceptible to injury. Under such conditions one treatment during the blooming season, if properly made, could not be expected to cause the loss of a large percentage of the crop of ripe fruit.

In the tests where the trees were sprayed repeatedly during the blooming season so as to hit as many as possible of the new blossoms which opened from day to day, but very few blossoms survived the treatment and consequently but little fruit set. This shows that the ordinary spray mixtures surely prevent the setting of fruit when applied to the blossoms soon after they open. If the tree should have a scant amount of blossoms it would seem that serious loss might result from such treatment.

In some cases the spray mixture had a corrosive effect and killed the tissues of the stamens and pistils. In other cases pistils with particles of the spray mixture on the stigmatic surfaces awaited fertilization for several days, apparently unharmed and perfectly healthy, but eventually withered and died. A number of blossoms were observed which showed particles of spray mixture on the stigmatic surfaces, but none of these set fruit. It appears therefore that in these cases the spray mixture inhibited

the process of fertilization and thus eventually caused the death of the entire blossom.

Blossoms which had been open several days before they were sprayed seem to have reached a stage where the treatment did not check the progress of fertilization, and the fruit set as abundantly as it did from corresponding blossoms which were not sprayed.

The Structure of an Apple Blossom and the Process of Setting Fruit.

The following brief description of the structure of the apple blossom and of the way in which it sets fruit may help some readers to a clearer understanding of the subject.

When the fruit bud of the apple tree opens it releases a cluster of blossom buds. Such clusters usually contain five or six blossom buds. The central one in the cluster is regularly the strongest, opens first, and sets first. Its fruit has the best chance of hanging on through the period when the weaker of the young fruits drop and of remaining till it ripens. Several or even all of the blossoms in a cluster may set fruit, but, if any of these pass successfully through the period when the young fruits drop, generally only one or perhaps two of them are left to ripen. Fig. 2, Plate LVII, shows a typical Baldwin cluster shortly after the blooming season passed and before the dropping of the weaker fruits began. It shows clearly the superiority of the central fruit in the cluster.

An apple blossom cut through the middle shows different parts as illustrated in Fig. 12. The outer green portion which covers the bud is the calyx. Where the blossom opens it turns backward as shown at *c*, Fig. 12, and *c*, Fig. 13. It remains after the fruit has developed as may be seen by examining the blossom end of a ripe apple. The showy white or pink tinged part of the flower is the corolla. Its separate leaves are called petals, *pt*, Fig. 12. If calyx and corolla be taken away it is still possible for fruit to develop. These are therefore not the essential organs. The essential organs are inside of the petals. They are the

stamens and the pistil. The stamens, *st*, Fig. 12, many in number, are next to the petals. They are thread like organs tipped with minute yellow sacs which are filled with a very fine yellow powder, the pollen. The pistil, *p*, Fig. 12, and *p*, Fig. 13, is in this case a compound one. It occupies the very center of the flower. It is united below and separates above into five green threads, which are known as styles. The enlarged tip of the style is given a separate name, the stigma, and its rough, sticky surface is known as the stigmatic surface, *s*, Fig. 12, and *s*, Fig. 13. Figure 13 gives the appearance of the flower with the petals and stamens cut off so that the parts of the pistil may be readily distinguished.

The part which finally develops into fruit, *o*, Fig. 12, and *o*, Fig. 13, called the ovary, has within the little egg cells called ovules, *ov*, Fig. 12, and *ov*, Fig. 13, which if the fruit sets, develop into the seeds. If a typical ripe apple be examined five cavities will be found in the core, each with two seeds. Likewise the center of the ovary has five cavities each with the two ovules ready to develop into seeds should they become fertilized, and each directly connected with the particular one of the five styles which is immediately above it. The stamens may be called the male organs of the flower; the pistil, the female. In order that the ovules may become fertilized the pollen which is produced by the stamens must in some way reach the stigmatic surface of the pistil. The pollen may be brought to the pistil by insects which pass from flower to flower, or it may reach it in some other way. The stigmatic surface of the pistil, when it is ready for the pollen, becomes covered with a sticky fluid which easily holds any of the pollen that happens to touch it. Within a few hours after the pollen reaches the stigmatic surface under favorable conditions, it sprouts and sends out a pollen tube in a way somewhat analogous to the sprouting of grain in warm, moist soil. Figs. 14 and 15 illustrate the germination of some Amaryllis pollen. The pollen tube grows downward through the soft tissues of the style till it reaches the ovule. From the pollen tube there then passes into the ovule a substance which

stimulates it to growing into a seed, or in other words, which fertilizes it. If fertilization does not take place there is no further development and the entire flower withers and dies.

The essential organs of the flower are composed of very tender tissues. It is not surprising that injury follows when they are hit by spray mixtures. Neither is it strange that Bordeaux mixture should prevent the growth of the pollen. Bordeaux mixture could not hold its position as a leading fungicide if it did not prevent the growth of fungus spores. The germination of a pollen grain is analogous to the germination of a fungus spore. Fig. 14 illustrates pollen grains of an Amaryllis and Fig. 15 shows their appearance after they have germinated and begun to send out the pollen tubes; Fig. 16 illustrates spores of a species of fungus which causes the carnation rust and Fig. 17 shows the same after they have germinated and sent out the germ tubes. Since Bordeaux mixture is deadly to the one it might reasonably be expected to have a similar effect upon the other. That it does have such an effect is demonstrated by the experiments in the laboratory and in the orchard, an account of which is given on the preceding pages.

EFFECT OF SPRAYING IN BLOOM UPON THE YIELD.

In order to get some evidence as to the effect of spraying apple trees in bloom upon the yield of fruit, and also upon injurious insects and plant diseases, as compared with spraying when the trees are not in bloom, four bearing orchards were sprayed in different parts of Western New York. These orchards were so free from fungous troubles during 1900 that no information was gained as to whether such diseases as the apple scab may be best controlled by spraying in bloom but the experiments did throw some light upon the effect on the yield, of spraying in bloom, although they are not conclusive on this point, as may be seen by the following account of the work.

Three of the orchards in which these experiments were conducted are near Lake Ontario and one is on the upland about five miles west of Seneca Lake. This arrangement was planned

so as to observe the effect of the treatment in widely separated orchards and under differences of environment. These orchards belong to the following named gentlemen: George H. Bradley & Son, Lake Road, Niagara County; F. D. Gardner, Barker, Niagara County; John B. Collamer & Son, Hilton, Monroe County; Thomas B. Wilson, Hall's Corners, Ontario County. These gentlemen put their orchards at the disposal of the Station for the purposes of this investigation, and throughout the season gave the work their cordial coöperation. Our thanks are due to them for this and for many courtesies extended to the representatives of the Station who conducted the experiments.

EXPERIMENTS AT LAKE ROAD.

In the orchard of Messrs. George H. Bradley & Son, Lake Road, three rows of trees on the north side of the orchard were included in the test. The accompanying plan gives an idea of the relative position of the trees under experiment. Those marked s were sprayed in bloom: corresponding trees which

N	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	Row 1
	△	o	o	o	△	o	△	△	△	△	△	△	△	△	△	△	△	△	△	△	Row 2
W E	△	o	o	△	o	o	△	△	△	△	△	△	△	△	△	△	△	△	△	△	Row 3
	s	s	s	△	s	s	△	△	△	△	△	△	△	△	△	△	△	△	△	△	Row 4
S	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	Row 5

were not sprayed in bloom are marked o. The trees thus indicated are all of the Hubbardston variety.

Treatment.—In all treatments Bordeaux mixture, 1-to-10 formula, and Paris green, 1 lb. to 160 gallons, were used. The trees in Rows 2 and 3 were first sprayed in part May 14; at this time the blossom buds had appeared but no blossoms were open. They were sprayed May 14 on one side and on the opposite side May 21. On the latter date the buds were far enough along to show the color of the flower but no blossoms were yet open on these trees, although Oldenburg had been in bloom since May 16.

On May 24 the blossoms were well open and the trees in row 4 were then sprayed very thoroughly so as to hit as many of the open blossoms as possible. Immediately after the blossoms had fallen, May 31, the trees in Row 2 and 3 were sprayed on the west side only and on June 6 they were sprayed on the east side only. The weather conditions did not appear to favor the development of the scab fungus and no spraying was done after this. The treatment given to these Hubbardston trees for the season may be thus stated.

Rows 2 and 3—sprayed just before blooming and just after blooming.

Row 4—sprayed just after coming into full bloom.

Effect of the spray upon the open blossoms.—Soon after the fruit set a comparison of those trees which had been sprayed in bloom with those not so sprayed showed very clearly that many blossoms had been killed by the spray. Although the bloom was so abundant that the loss of these blossoms could not be expected to make much difference in the yield of fruit yet at the close of the season the record of the yield actually showed less fruit on the average where the trees were sprayed in bloom than where they were not.

With the assistance of Mr. Bradley the following estimate of the amount of bloom on each tree was made May 24.

Row 2: Not sprayed in bloom.	Row 3: Not sprayed in bloom.	Row 4: Sprayed in bloom.
No. 15 heavy.	No. 15 heavy.	No. 15 heavy.
No. 17 heavy.	No. 16 medium.	No. 16 medium.
No. 18 heavy.	No. 18 heavy.	No. 18 heavy.
No. 19 heavy.	No. 19 heavy.	No. 19 heavy.
		No. 20 heavy.

An idea of the climatic conditions during the spraying season in Niagara County at Lake Road as compared with those in Ontario County at Geneva may be obtained from the following table. The observations for Niagara County were made free of charge by Mr. H. A. Van Wagoner, to whom our thanks are due for this favor. The table shows the average of three daily readings of maximum and minimum thermometer, relative humidity,

and also the amount of rainfall at Lake Road and Geneva for 7 weeks—May 12 to June 29.

TABLE XIV.—PARTIAL METEOROLOGICAL RECORD, LAKE ROAD AND GENEVA, MAY 12–JUNE 29.

Date.	Average max.	Average min.	Average humidity.	Total rainfall.
LAKE ROAD.				
May 12–18	71	48	76	0.33
May 19–25	69	45	63	0.02
May 26–June 1	74	51	77	0.25
June 2–8	74	55	80	0.53
June 9–15	74	51	73	0.17
June 16–22	74	51	68	0.15
June 23–29	84	59	63	0.06
				Total
Average	74.3	51.4	71.4	1.51
GENEVA.				
May 12–18	76	51	65	0.72
May 19–25	70	48	56	0.00
May 26–June 1	78	48	63	0.62
June 2–8	80	55	67	0.65
June 9–15	77	50	61	0.11
June 16–22	80	54	53	0.05
June 23–29	88	60	53	0.14
				Total
Average	78.4	52.3	59.7	2.29

It is interesting to note that while the rainfall was greater at Geneva the average humidity was decidedly less and the temperature was higher and subject to somewhat greater extremes at this place than it was at Lake Road.

The conditions during the summer remained favorable to the healthy development of foliage and fruit except that the drought was severe. High winds at different times, and especially the wind storm of September 11 and 12, caused the loss of a considerable amount of fruit.

Yield of fruit.—In order to get as accurate a record as possible of the effect of the spraying in bloom upon the yield even the windfalls which were unfit for any use were measured and the record of the amount of this fruit for each tree was included in making the statement of the total yield of fruit per tree. On

October 13, the crop of fruit was gathered. The picked fruit was sorted into but two grades, namely barrel-fruit and culls.

The apples were quite free from scab and insect injury. Some fruits had been attacked by late brood codlin moth, but the greater part of the culls consisted of apples which were too small to barrel. It was very noticeable that there was a much larger percentage of fruit too small to barrel in Row 4, which had been sprayed in bloom, than from either Row 2 or 3 which were not so sprayed. The fruit from Rows 2 and 3 averaged so much larger in size that Mr. Frank Bradley estimated that it would sell at from 25 cents to 50 cents more per barrel than the fruit from Row 4. At the ruling prices this was a gain of from 20 per ct. to 40 per ct. in price in favor of the fruit from trees not sprayed in bloom.

Why the fruit from the trees sprayed in bloom should in this test grade smaller and in other tests grade larger than trees not sprayed in bloom is not quite clear. Possibly because the spraying was done at a time when it killed a large percentage of the first blossoms to open. These are the strong, vigorous blossoms in the center of the cluster, which usually take the lead in growth and which naturally may be expected to make the largest fruit. Perhaps there were more small apples in Row 4 because next south of it in Row 5 stood large, thrifty Baldwin trees. These Baldwins doubtless sent vigorous roots into the soil, towards the Hubbardston trees and made it somewhat more difficult for trees in Row 4 to get the material with which to make large fruit than it was for the trees in Rows 2 and 3 which were surrounded by trees much smaller than the Baldwins.

The following table shows the total yield for each tree.

TABLE XV.—TOTAL YIELD OF HUBBARDSTON APPLE TREES.

	Sprayed in bloom. Total number bushels.		Not sprayed in bloom. Total number bushels.
Row 4:		Row 2:	
Tree No. 15.....	13.	Tree No. 15....	13.25
16.....	9.50	17....	12.75
18.....	18.25	18....	8.25
19.....	9.25	19....	23.75
20.....	14.75	Row 3:	
		Tree No. 15....	8.50
		16....	10.75
		18....	12.25
		19....	19.00
[1] Average per tree..	12.95	....	13.56
Average apparent gain for trees not sprayed in bloom			.61

In the following table the average amount per tree of the different classes of fruit is shown for each of the treatments.

TABLE XVI.—AVERAGE YIELD PER TREE OF GRADED FRUIT FROM HUBBARDSTON TREES.

	Not sprayed in bloom. Average bushels per tree.	Sprayed in bloom. Average bushels per tree.
Total picked fruit......................	8.56	8.20
Barrelled fruit	7.50	6.60
Culls	1.06	1.06
Drops	5.00	4.75
Total yield per tree..................	13.56	12.95

The apparent average loss per tree from spraying in bloom was nine-tenths of a bushel of marketable fruit, but including all grades it was only six-tenths of a bushel. With trees standing 30x30 feet apart, making 48 trees per acre, the loss of marketable fruit at this rate amounts to 43 bushels per acre. This fruit would have readily sold at picking time for $1.25 per barrel so that the apparent loss in yield might be conservatively esti-

[1] It should be noted that tree No. 18 of Row 2 was somewhat smaller than the other trees under experiment: also tree No. 16 of Row 3 and tree No. 16 of Row 4 had but a medium amount of bloom. If these are excluded the average yield per tree of those sprayed in bloom is 13.56 bushels and the average per tree for trees not sprayed in bloom is 14.91 bushel per tree. In this case the average for trees sprayed in bloom is 1.35 bushels per tree less than for trees not sprayed in bloom.

mated at $18 per acre. This is an item of much less importance however, than the difference in the market value of the fruit which, as before stated, Mr. Bradley estimated at 25 cents to 50 cents per barrel in favor of the trees not sprayed in bloom. The average yield of the trees sprayed in bloom was 12.95 bushels. With 48 trees per acre this would amount to 621.6 bushels or 207.2 barrels per acre. A loss of 25 cents per barrel on this number of barrels amounts to $51.80, which combined with the apparent loss in yield of $18 makes the total loss in this experiment at the lowest estimate about $70 per acre. This estimate is presented here to show the apparent loss from spraying in bloom in this particular test. It is given as simply one item of evidence bearing upon the general subject under investigation. It is not supposed that it furnishes an accurate standard for estimating the probable loss from such treatment in other localities and seasons. As stated before it is not clear whether the fruit in Row 4 was smaller than that in Rows 2 and 3 because of the treatment or because of the location of the trees.

EXPERIMENTS AT HILTON.

In the orchard of Messrs. John B. Collamer and Son, Hilton, Monroe County, several varieties were treated. These trees were planted about 20 years ago and about 10 years ago were top-worked. They average from 17 feet to 20 feet high and stand 30 feet apart. Two trees of Oldenburg were sprayed in bloom and two other trees which were selected as being as near like these as possible were not sprayed in bloom. All of these trees were sprayed alike on the west side May 4 before the blossoms opened, but after the leaf buds had opened, using Bordeaux mixture, 1 to 10, and sodium arsenite at the rate of 1 pound of white arsenic to 200 gallons of the mixture, which is equivalent to 1 pound of Paris green to 100 gallons.

The Oldenburg trees which were sprayed in bloom were treated Saturday, May 19, about four days after the blossoms began to open. After the blossoms had fallen, May 29, the corresponding trees which had not been sprayed in bloom were

sprayed on the east side only. Later they were sprayed on the opposite side.

Three trees of Alexander, 6 of Twenty Ounce, 4 of Pumpkin Sweet (commonly called *Pound Sweet*), 3 of Baldwin and 3 of Hubbardston were similarly sprayed in bloom and an equal number of corresponding trees of the same varieties not sprayed in bloom were compared with them.

Observations later showed that on the treated trees many blossoms had been destroyed by the treatment. On the treated Baldwin the fruit which had set generally developed either from the very early or from the late blossoms. Plate LVII, Fig. 1, shows a treated cluster in which no fruit has developed except possibly one from a late, outside blossom. On corresponding Baldwin trees which were not sprayed in bloom, not only had the center blossom of the cluster generally set, but often two or three or more of the other blossoms of the cluster had also set fruit as shown in Table XII and illustrated by Fig. 2, Plate LVII.

These results indicate that at the time when the spraying was done the earliest of these Baldwin blossoms were already too far advanced and the latest were not open enough to be injured by the spray, while the lately opened mid-season blossoms generally succumbed to the treatment, probably because the process of fertilization had not yet progressed far enough to place them beyond danger from the poisonous effect of the spray mixture. For a comparison of the number of blossoms which set on the Baldwin and Pumpkin Sweet which were sprayed in bloom and on the corresponding trees not sprayed in bloom, see p. 393. On the Oldenburg trees the earliest blossoms to open were generally the ones which were killed by the spray; in many cases only the center blossom of the cluster was killed. The fruit which set on Oldenburg sprayed in bloom generally developed from the blossoms which opened in mid-season or later.

When the June drop of fruit occurred, Mr. Collamer reported that he could see no difference between the trees sprayed in bloom and those not so treated in the percentage of the fruit

which dropped. The difference in the amount of fruit on trees of Alexander, Twenty Ounce and Oldenburg which were sprayed in bloom and corresponding trees of these varieties which were not so treated was not great enough to be determined from inspection as late as August 16. The Oldenburgs were picked August 21 and graded by Mr. Collamer into three grades as shown in his report which follows. No record was kept of the drops, but the amount was relatively large when compared with the amount of picked fruit.

TABLE XVII.—YIELD OF OLDENBURG APPLE TREES.

Class of fruit.	Not sprayed in bloom. Yield in pounds.	Sprayed in bloom. Yield in pounds.
Total yield from 2 trees	267	227
No. 1, from 2 trees	176 or 66 per ct.	151 or 67 per ct.
No. 2, from 2 trees	82 or 31 "	65 or 29 "
No. 3, from 2 trees	9 or 3 "	11 or 4 "
Average yield of picked fruit per tree.	134	114

From this it appears that the average loss of picked fruit per tree was 20 lbs., or about two-fifths of a bushel. It is but fair to say that this variety, the Oldenburg, is not well adapted for a test of the effect of spraying in bloom on the yield, because the fruit does not ripen so that it can all be picked at once, and consequently it is not easy to keep an accurate record of the drops and of the different grades of marketable fruit.

Four trees of Pumpkin Sweet were sprayed in bloom, and four corresponding trees were not sprayed in bloom. On August 16 the following notes on these trees were made:

Row 3, sprayed in bloom.

Tree 1.—No fruit on the tree.
Tree 2.—But little fruit on the tree.
Tree 3.—But very little fruit on the tree.
Tree 4.—But very little fruit on the tree.

Row 4, not sprayed in bloom.

Tree 1.—But very little fruit on the tree.
Tree 2.—But very little fruit on the tree.
Tree 3.—But very little fruit on the tree.
Tree 4.—But very little fruit on the tree.

So far as the influence of spraying in bloom upon the yield is concerned it is evident that this test with the Pumpkin Sweet is inconclusive, because there was very little fruit produced by either the treated or the untreated trees.

Three trees of Baldwin were sprayed in bloom and three corresponding trees were not so sprayed. On August 16 the following notes were made.

Row 3—sprayed in bloom.—Tree 5: Lower limbs except on west and north are well loaded. The rest of the tree has a fair crop. Tree 6: A good crop and quite evenly distributed. Tree 7: A fair crop on south and east parts of the tree. The rest of the tree has a light crop.

Row 4—not sprayed in bloom.—Tree 5: Except on the northwest the tree is well loaded and the crop quite evenly distributed. Tree 6: A fair crop and quite evenly distributed. Tree 7: A light crop.

On account of the variability in the yield of the different Baldwin trees which received the same treatment a larger number of trees should be tested in order to get satisfactory evidence as to the effect of the treatment on the yield.

EXPERIMENT AT HALLS CORNERS.

Spraying in bloom was tested on Baldwin and Rhode Island Greening trees in the orchard of Thomas B. Wilson, Halls Corners, N. Y. A row containing 14 Baldwin trees was sprayed in full bloom and the same number of trees in the next row which were not sprayed in bloom were selected for comparison with them. Five Rhode Island Greening trees were sprayed on one side only while in bloom and one was sprayed on both sides. The portions of the five trees which were not sprayed in bloom were to be used for comparison with the sprayed portions. The trees selected for the experiment have been planted 29 years. They are quite uniform in size and generally are in good health and productive condition.

Treatment.—The first treatment was given to all of the trees

under experiment. It was made May 7, after the leaf buds opened but before any of the blossoms were open.[1]

The second treatment for the trees which were sprayed in bloom was made May 21, to 14 Baldwin and one R. I. Greening tree and to the north side of five other R. I. Greening trees. This spraying was done with especial thoroughness so as to hit as many of the open blossoms as possible. Nearly all of the blossoms were open at this time. The trees showed an unusual abundance of bloom. The second treatment for the corresponding trees which were not sprayed in bloom was not given till May 29 and June 1 when the trees were just out of bloom. At this time 14 other Baldwin trees were sprayed and also the south side of the five R. I. Greenings which had been sprayed on the north side May 21. This treatment was made just as thoroughly as the treatment of May 21.

The third treatment was given to all trees alike June 11. The fruit was then about the size of cherries.

In all these treatments Bordeaux mixture, 1 to 10, was used combined with sodium arsenite. The latter was used at the rate of ¾ lb. of the white arsenic from which it was made to 100 gallons of the spray mixture.

Effect of the spray upon the open blossoms.—The trees which had been sprayed in bloom were examined May 29 and it was evident that very many of their blossoms had been killed by the treatment. Nevertheless the bloom had been so abundant that including the comparatively few, but really large number, which had escaped injury because they were not open May 21, there were enough blossoms which were not hit by the spray, to provide for a fair to good setting of fruit. Even on trees which were not sprayed in bloom Mr. Wilson estimated that 90 per ct. of the

[1]The row of Baldwin trees not sprayed in bloom was treated with Bordeaux mixture alone May 4 just after the leaf buds opened but the rain interfered with continuing the treatment to the row which was to be sprayed in bloom. On May 7 they were treated with Bordeaux and sodium arsenite as were also the trees which were to be sprayed in bloom. This is what is called above the "first treatment."

blossoms failed to set yet enough did set to provide a considerable crop of fruit.

Yield of fruit.—The Greening trees under experiment suffered the loss of so much of their fruit in the wind storm of September 11 and 12 that no record could be made of the yield of the part sprayed in bloom as distinct from the part not sprayed in bloom. So far as could be determined by inspection only, there was no decided difference between them.

The Baldwins suffered much less loss of fruit during the wind storm referred to than did the Greenings. Since the trees of this variety which were sprayed in bloom were in a separate row from the trees with which they were to be compared, the amount of the drops could be ascertained and the record of their yield was therefore kept.

The amount of all the windfalls is included in the record of the total yield of fruit as given in the following statement. It appears from this statement that the drops amounted to about one-third of the total yield. An inspection of the fruit both before and after it was picked led to the opinion that the color of the fruit was better where the trees were not sprayed in bloom than it was where they were sprayed in bloom, but in size and quality there was no decided difference.

TABLE XVIII.—YIELD OF BALDWIN APPLE TREES.

	Not sprayed in bloom.	Sprayed in bloom.
Total bushels picked from 14 trees....	129	127.5
Total bushels drops..................	66	61.1
Total yield	195	188.5
Average yield per tree................	13.9	13.5

From this it appears that the average yield per tree was two-fifths of a bushel less where the trees were sprayed in bloom than where they were not so treated. The trees sprayed in bloom averaged 6¾ bushels No. 1 picked fruit while the corresponding trees not sprayed in bloom averaged 6¼ bushels. Did thinning of the fruit by spraying in bloom have the same effect as thinning by other methods, and cause this larger yield of No. 1 fruit

with a smaller total yield than that of the corresponding trees not sprayed in bloom?

EXPERIMENTS AT BARKER.

In the orchard of Mr. F. D. Gardner, Barker, N. Y., several varieties were sprayed in bloom. These trees have been planted 27 years and are from 15 ft. to 20 ft. high. They stand 34 ft. apart. They were treated as stated below:

May 11....	Sprayed all alike before blossoms opened.
May 19....	Sprayed Tompkins King and Twenty Ounce in Rows 5 and 7. These were then in full bloom.
May 24....	Sprayed Roxbury Russet and Rhode Island Greening in Row 5 which were then in full bloom.
May 28....	Just after blossoms had fallen, sprayed Tompkins King in Row 8 and Twenty Ounce in Row 9.

The accompanying plan shows the relative position of the trees under experiment.

PLAT OF PORTION OF ORCHARD UNDER EXPERIMENT AT BARKER.

N	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	O^1	O^1	Row 9
	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	O^2	Δ	Δ	Row 8
W E	O^4	O^4	Δ	O^4	Δ	O^4	O^3	O^3	S^2	S^1	S^1	Row 7
	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Row 6
S	Δ	S^4	Δ	Δ	Δ	S^4	S^3	S^3	S^3	S^1	S^1	Row 5

"S" indicates trees sprayed in bloom.
"O" indicates trees not sprayed in bloom.
1 indicates Twenty Ounce trees.
2 indicates Tompkins King trees.
3 indicates Roxbury Russet trees.
4 indicates Rhode Island Greening trees.

In all treatments Bordeaux mixture, made by using one pound of copper sulphate for $6\frac{1}{4}$ gallons, and Paris green at the rate of 1 lb. to $133\frac{1}{3}$ gallons, were used. The Twenty Ounce and Tompkins King came into bloom earlier and so were sprayed in bloom several days before the Roxbury Russet and Rhode Island Greening were so treated. The treatment was made very thoroughly. Little air was stirring and it was possible to spray and do excellent work from either side of the tree. But even with most thorough treatment some of the open blossoms were

not hit in the center by the spray and of course these escaped injury.

Effect of the spray on the open blossoms.—The trees sprayed in bloom May 19 were examined May 24. At that time there was apparently but little injury from spraying the open blossoms but on June 5 these trees and also those which were sprayed in bloom May 24 showed great numbers of clusters in which part or all of the blossoms had died from the effect of the spray. This injury could be readily recognized when the trees which had been sprayed in bloom were compared with corresponding trees not so treated.

With the assistance of Mr. Gardner the following estimate was made of the amount of bloom on the trees under test.

Twenty Ounce all very heavy.

Tompkins King all very heavy.

Roxbury Russet sprayed in bloom; one light, one heavy.

Roxbury Russet not sprayed in bloom; one light, one medium.

Rhode Island Greening sprayed in bloom; both very heavy.

Rhode Island Greening not sprayed in bloom; two light, two very heavy.

Mr. Gardner reported June 29 that there was practically no difference in the drop of fruit from the two lots of trees under test; all were holding the fruit well. During the summer the foliage remained healthy and the fruit fair and free from scab or other disease. The Twenty Ounce fruit was somewhat russeted from the effect of the spraying in bloom. An inspection of the trees of this variety August 17 showed but little if any difference in the amount of fruit on trees sprayed in bloom and the trees not so treated. On the other hand there seemed to be decidedly less fruit on Roxbury Russet trees sprayed in bloom than on the corresponding trees which did not receive this treatment. The same was true of R. I. Greening. On Tompkins King, the spraying in bloom also seemed to have thinned the fruit somewhat.

In October, when the fruit was picked, there was so little fruit on any of the Roxbury Russet trees under test that it was of no use to keep the record of the yield. Through an oversight

the yield of the Twenty Ounce not sprayed in bloom was not recorded so that no comparison can be made with the corresponding trees which were sprayed in bloom other than was made August 17 as noted above.

Two of the R. I. Greening trees which were not sprayed in bloom had a light bloom. Since there were no corresponding trees with light bloom in the row which was sprayed in bloom these two trees were not taken into account in making the averages for the table.

It appears from this table that Tompkins King sprayed in bloom yielded 1½ bushels less fruit per tree than corresponding trees not sprayed in bloom, yet the amount of marketable fruit was not diminished. The R. I. Greening trees which were

TABLE XIX.—YIELD OF TOMPKINS KING AND R. I. GREENING APPLE TREES.

Name of variety	Not sprayed in bloom.		Sprayed in bloom.	
	No of trees under test.	Average bushels per tree.	No. of trees under test.	Average bushels per tree.
Tompkins King........	1		2	
No. 1................		9.25		9.00
No. 2................		3.00		3.25
Culls		.75		.75
Drops		2.00		.50
Total yield..........		15.00		13.50
R. I . Greening........			2	
No. 1................		9.38		9.88
No. 2................		2.50		1.75
Culls		3.75		1.75
Drops		2.00		3.00
Total yield..........		17.63		16.38

sprayed in bloom yielded 1¼ bushels less per tree than trees not so sprayed, but the loss of the marketable fruit was only one-fourth bushel per tree. In these cases, as with the Baldwin trees in Mr. Wilson's orchard, spraying in bloom thinned the fruit and the thinning done in this way seemed to produce results in some respect similar to those obtained when the young fruit is thinned by hand, that is to say the total yield was decreased but the yield of marketable fruit was but slightly lessened or was even somewhat increased. The experiment with the Hubbardston at Mr. Bradley's, however, gave contrary results, and further tests are needed to establish a safe general conclusion on this point.

ACKNOWLEDGMENTS.

The photographs for Plates LVI, LVII and LVIII were made under the author's direction by Professor W. Paddock, and the drawings for Figures 12 to 17 were made at his request by Mr. Heinrich Hasselbring. Mr. O. M. Taylor assisted in taking the records of yields and in the tests which were made in the Station orchards. The assistance which these gentlemen rendered is thankfully acknowledged.

REPORT

OF

Inspection Work.

W. H. Jordan, *Director.*
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Table of Contents.

INSPECTION OF CONCENTRATED COMMERCIAL FEEDING STUFFS DURING THE SPRING OF 1900.*

W. H. Jordan and C. G. Jenter.

FEEDING STUFFS LEGISLATION.

The Legislature of New York at its session of 1899 enacted a law having for its purpose the regulation of the sale and inspection of concentrated commercial feeding stuffs. This law constitutes chapter 510, Laws of 1899, which amends chapter 338, Laws of 1893. In order to make more clear one of its provisions it has been since amended, as per chapter 79, Laws of 1900.

REASONS FOR SUCH LEGISLATION.

The primary occasion for such legislation is the introduction into our markets of a great number of by-products from various manufacturing processes which are more or less useful and valuable for feeding farm animals, such as the oil meals, wastes from the manufacture of starch and glucose, brewers' residues, by-products from the preparation of breakfast foods and the offals from the milling of wheat, rye and buckwheat.

Such materials differ widely in composition and nutritive value, a fact which takes on great significance when we learn that these feeding stuffs are not always sold under their correct names and that the inferior ones are often used to adulterate those of a high grade in a way not easily detected. The cheapening of cottonseed meal by grinding into it a proportion of hulls, the mixing of gluten products with corn meal, the extensive adulteration of mixed feeds with oat hulls and of wheat bran with corn cobs

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*Reprint of Bulletin No. 176.

or similar substances, are examples of existing practices against which it is sought to defend the farmer by legal enactment.

Not only are dishonest practices more or less prevalent in the feeding stuffs trade as in every other, but the names popularly applied to commercial cattle foods can not be depended upon as an indication of composition. Much confusion exists in the names applied to the starch and glucose wastes especially. The claims made for mixed feeds are not always justified by the actual composition of these materials. For these reasons it is essential and right for the consumer to be furnished with reliable information concerning the substances that he is buying.

THE PROVISIONS OF THE LAW.

The following is a summary of the provisions of the concentrated feeding stuffs law:

(1) The law defines the term "concentrated commercial feeding stuffs." It is made to include linseed meals, cottonseed meals, pea-meals, cocoanut meals, gluten meals, gluten feeds, maize feeds, starch feeds, sugar feeds, dried brewers' grains, malt sprouts, hominy feeds, cerealine feeds, rice meals, oat feeds, corn and oat chops, ground beef or fish scraps, mixed feeds and all other materials of similar nature.

The following materials are excluded from this term: Hays and straws, and the entire grains of wheat, rye, barley, oats, maize (corn), buckwheat and broom corn, either whole or ground into meal; also bran and middlings from wheat, rye and buckwheat when sold as such.

(2) It is required that a statement shall be affixed to the bags or other packages in which feeding stuffs are sold, giving the following facts:

Trade name of feeding stuff,
Name of manufacturer and place of business,
Place of manufacture,
Percentage of protein,
Percentage of fat.

If the goods are sold in bulk the dealer must furnish the buyer upon request the same statement that is required on bags.

(3) The manufacturer, dealer or other responsible party must file with the Director of the New York Agricultural Experiment Station annually during December the same statement that is required on the bags, and furnish a sample of each feeding stuff, if the Director so requests. Samples so furnished are not for analysis.

(4) A license fee of $25 on each and every brand of concentrated feeding stuff sold or offered for sale is to be paid to the Treasurer of the New York Agricultural Experiment Station annually during December.

If the manufacturer or importer or shipper files the required statements and pays the fee for the whole State no one else is required to pay, but otherwise every retail dealer in the State is liable. (It is expected that this law will operate as does the fertilizer law, where, without exception, the manufacturers or importers pay the required fees.)

(5) The Director of the Station is to collect in the open market samples of the feeding stuffs coming within the provisions of this law and cause them to be analyzed. The information so secured shall be published from time to time in bulletins or reports.

(6) The adulteration of the cereal grains, corn, oats, etc., with milling or manufacturing waste products, as for instance grinding oat hulls into corn, is made illegal, unless the substances in the mixture are clearly stated on the package.

(7) Proper penalties are named for the violation of the provisions of this law.

(8) The Director of the Station shall report violations of the provisions of the law to the Commissioner of Agriculture, who shall prosecute the party or parties thus reported.

The essential provisions of a feeding stuffs inspection law which will be mainly influential in promoting a better condition in the feeding stuffs trade are the guaranteed bag markings and public statement of composition, the annual official record of the

trade brands and guaranteed composition at the Experiment Station, and the annual inspection by State officials.

It will be noticed that this law is quite similar in its provisions to the fertilizer laws which have been in successful operation in many States during the past twenty-five years. It is a recognition of the right of every purchaser of cattle foods to know what he is buying, and of the duty of the manufacturer or dealer to comply with his advertised statements.

OBJECTIONS TO THE LAW.

When the New York law was first proposed some interested parties feared that it would be inimical to trade interests.

It was thought that the license fee would prove to be a financial burden. It was not understood by all that the payment of a single fee by the manufacturers would meet the provisions of the law for the whole State. and that the dealers would probably bear no direct expense whatever. Of course manufacturers, especially those in other States, may refuse to pay this fee, but this would be a short sighted policy, as it would most certainly in the end result in shutting their goods out of New York trade. Such a refusal could not reasonably be based on the claim that this fee is a heavy money tax. Even if a manufacturer is putting out not over 100 tons annually, which is rarely the case, the tax per ton would only be 25 cents. In most cases where the output is hundreds and even thousands of tons the added expense of production is too small to be appreciated. Some of the small millers of the State may regard the license fee and cost of the necessary chemical analyses as an expense altogether too large, and it is well to remind all such that if they confine their business to the entire cereal grains, either separate or mixed, and to the offals from the cereal grains, and refrain from buying oat hulls or other by-products to mix with the ground grains, the law will in no way affect them. If they deal in such standard feeds as the oil meals, gluten products and brewers' residues no fee will be required in most cases, because it generally will be paid by the manufacturer.

It is proper for the interested public to know that the total income to the State from license fees on concentrated feeding stuffs for the year 1900 will not exceed $2,600, which can neither be a burdensome tax upon a business that involves hundreds of thousands of tons of material, nor a large sum of money with which to inspect these goods.

Objection has been made to the guaranteeing of the analysis of by-product commercial feeding stuffs on the ground that because of natural variations in the grains from which they are made their composition is not uniform. The answer to this is, that while the proportions of protein and fat in the unmixed by-products do vary within certain limits, there are minima that may be used as the guarantees below which these percentages rarely fall. In the mixed feeds containing several components the composition is in the control of the manufacturer. Moreover, it is expected that in this particular common sense will prevail in the execution of inspection laws. It is possible to so administer affairs that only willful violators of the law will feel its force. Similar provisions relative to fertilizers have been in force in some states for over twenty-five years; and honest manufacturers and dealers, while sometimes inconvenienced, have suffered no hardships therefrom.

COMPLIANCE WITH THE LAW.

It is probably too early to reach any conclusions as to how fully it will be possible to secure compliance with this new law. Already, so far as known, the manufacturers of the leading brands of commercial feeding stuffs have met its provisions. Doubtless some local mills and perhaps other parties are still doing an illegal business. In the single inspection which has so far been instituted, it has not been possible to reach every portion of the State and so some goods have up to this time escaped attention. Ultimately, however, cases of violation will be reached and they will then be treated as good judgment seems to indicate.

Those who find it necessary to purchase feeding stuffs should remember that they will largely determine the extent to which the law is obeyed. If they refuse to buy goods not properly marked or for which no guaranteed analysis can be furnished, dealers will not handle such, and when dealers refuse to handle a particular brand the manufacturer will be obliged to comply wth the law if he protects the interests of his business. It would be difficult at the present time to sell unmarked fertilizers in New York and the same condition may be made to prevail in the feeding stuffs trade.

It will certainly be the effort of the Experiment Station to give proper support to those manufacturers who meet the situation squarely and to warn dealers and consumers against purchasing materials, the character and composition of which the manufacturers are not ready to declare. The payment of the license fee is a matter to be settled between the dealers and the manufacturers. While the retail dealer is the liable party, especially in selling goods coming from without the State, it is certainly in the interests of convenience and economy for a single party, either the manufacturer or importer, to pay the fee once for all and thus prevent each and every dealer from being liable to this payment.

POLICY OF ENFORCEMENT.

It is generally conceded that the object of law is to secure proper conditions in those matters to which law pertains. In this particular case the object is to aid in promoting honesty and intelligence in the cattle food trade. It is believed that this result can best be reached by educational methods, reserving penalties for those cases of persistently willful and dishonest violation of the reasonable requirements which the law imposes. To drive an unscrupulous manufacturer or dealer out of his dishonest practices is the main good to reach and if this can be done without an appeal to the courts it is really better then to resort to litigation. It has been found in fertilizer inspection that the desire to stand well in the published results of inspection is an important factor in causing a careful attention to legal

provisions. At the same time the fact that the courts may be used and, if necessary, will be, is not forgotten; and will not be in inspecting feeding stuffs.

LIST OF LICENSED BRANDS.

There is given in this connection a list of the brands of feeding stuffs relative to which all the requirements of the law have been met so far as known.

The various feeding stuffs named under this head are recommended to the trade as those which dealers may handle at the present time without violating a State law and which consumers may purchase with a good degree of assurance as to the general character of what they are buying.

TABLE I.—MANUFACTURERS AND IMPORTERS WHO HAVE COMPLIED WITH THE NEW YORK FEEDING STUFFS LAW FOR THE YEAR 1900, WITH A LIST OF BRANDS SO GUARANTEED AND THE GUARANTEES.

License number.	Manufacturer or jobber. Name.	Address.	Name of feed.	Guaranteed. Protein.	Fat.
				Per ct.	Per ct.
53	Abbey, Stephen, & Sons,	Kingston,	Nebraska chop,	12.40	5.62
27	Acme Mills,	Olean,	Acme feed,	9.70	4.41
6	Akron Cereal Co.,	Akron, O.,	Chop No. 1,	7.94	4.18
	Akron Cereal Co.,	Akron, O.,	Royal oat feed,	8.25	4.14
18	American Cereal Co.,	Chicago, Ill.,	Quaker dairy feed,	12.03	2.50
	American Cereal Co.,	Chicago, Ill.,	Victor corn and oat feed,	8.23	3.00
	American Cereal Co.,	Chicago, Ill.,	Schumacher's stock feed,	10.79	3.28
	American Cereal Co.,	Chicago, Ill.,	Buckeye wheat feed,	16.21	4.48
	American Cereal Co.,	Chicago, Ill.,	Vim oat feed,	6.30	2.58
	American Cereal Co.,	Chicago, Ill.,	X oat feed,	6.30	2.58
	American Cereal Co.,	Chicago, Ill.,	American poultry food,	13.65	3.96
5	American Cotton Oil Co.,	New York, etc.,	Cottonseed meal,	43.0	9.0
31	American Linseed Co.,	New York, etc.,	Oil meal,	32—36	4—7
66	American Malting Co.,	Chicago, Ill., etc.,	Malt sprouts,	26.25	1.01
43	American Malting Co.,	Detroit, Mich.,	Hominy feed,	8.89	7.06
81	Archer Starch Co.,	Bradley, Ill.,	Gluten feed,	21.65	3.50
4	Bagley, G. W., & Son,	Peekskill,	Mixed feed,	12.44	4.65
55	Banner Food Co.,	Auburn,	Banner stock food,	26.25	8.78
	Banner Food Co.,	Auburn,	Banner poultry food,	26.78	6.90
14	Barwell, J. W.,	Waukegan, Ill.,	Blatchford's calf meal,	27.12	6.80
10	Bowker Fertilizer Co.,	Boston, Mass.,	Bowker's animal meal,	30.0	5.0
12	Brooks Griffiths Co.,	Minneapolis, Minn.,	Royal mixed feed,	16.61	5.48
22	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Cerealine feed No 1,	9.0	5.82
	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Cerealine feed No. 2,	10.31	8.62
1	Chapin & Co.,	Buffalo,	Prime cottonseed meal,	43.0	9.0
	Chapin & Co.,	Buffalo,	Hominy feed,	11.0	8.0
26	Commercial Milling Co.,	Detroit, Mich.,	Dandy corn and oat chop feed prov.,	10.81	6.02
45	Crescent Mfg. Co.,	Allegany,	Chop feed,	8.40	3.58
21	Crittenden, M. L.,	Buffalo,	Sterling provender,	8.82	5.55

65	Crittenden, M. L.,	Buffalo,	"999,"	10.27	4.43
78	Crittenden, M. L.,	Buffalo,	Corn feed,	11.82	4.82
33	Crow & Williams,	Sing Sing,	C. & W. mixed feed,	10.0	4.5
69	Cullen, Andrew, Co.,	New York,	Crescent oat feed,	11.0	7.35
8	Daisy Roller Mill,	Milwaukee, Wis.,	Daisy mixed feed,	16.94	4.6
72	Decatur Cereal Mill Co.,	Decatur, Ill.,	Hominy feed,	11.83	9.18
73	Diamond Mills,	Buffalo,	Diamond corn and oat feed,	9.44	4.78
68	Ellicottville Milling Co.,	Ellicottville,	Chop feed,	10.38	4.14
59-d	Elsworth, Edw., & Co.,	Buffalo,	De-Fi feed,	8.30	3.0
29	Empire Mills,	Olean,	Empire feed,	7.63	2.97
56	Finn, H., & Sons,	Syracuse,	Ground meat and bone,	45.-51.	15.-22.
20	Glucose Sugar Refining Co.,	Chicago, Ill.,	Chicago gluten meal,	36.0	4.0
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Fancy corn bran,	13.5	3.0
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Buffalo gluten feed,	27.0	3.3
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Rockford diamond gluten feed,	27.0	3.3
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Davenport gluten feed,	27.0	3.3
	Glucose Sugar Refining Co.,	Chicago, Ill.,	Marshaltown gluten feed,	27.0	3.3
80	Glucose Sugar Refining Co.,	Chicago, Ill.,	Germ oil meal,	25.0	10.5
49	Goeke, F. W., & Co.,	St. Louis, Mo.,	Barley malt sprouts,	23.48	1.68
36	Haskell, W. H., & Co.,	Toledo, O.,	Hominy feed,	9.75	8.28
50	Hauenstein & Co.,	Buffalo,	O. P. linseed meal,	39.62	8.53
63	Hayt, S. G.,	Corning,	Corn and oat chop feed,	10.00	4.0
16	Heath, H. R., & Sons,	Fort Dodge, Ia.,	Yankee corn and oat feed,	8.96	4.33
59	H. O. Company,	Buffalo,	H. O. Co.'s horse feed,	12.00	4.50
	H. O. Company,	Buffalo,	H. O. Co.'s dairy feed,	18.00	4.50
	H. O. Company,	Buffalo,	H. O. Co.'s poultry feed,	17.00	5.50
24	Hottelet & Co.,	Milwaukee, Wis.,	Malt sprouts,	28.96	1.66
39	Hotton Bros.,	Portville,	Common feed,	8.78	4.85
3	Hudnut Co.,	Terre Haute, Ind.,	Hominy feed,	12.85	8.52
60	Hunter Bros.,	St. Louis, Mo.,	Hominy feed,	12.16	6.44
70	Husted Milling Co.,	Buffalo,	Chop feed,	9.19	3.45

TABLE I—*Continued.*

License number.	Manufacturer or jobber. Name.	Address.	Name of feed.	Guaranteed. Protein.	Fat.
				Per ct.	*Per ct.*
79	Imperial Milling Co.,	Toledo, O.,	Special hominy feed,	7.87	5.67
17	Indianapolis Hominy Mills,	Indianapolis, Ind.,	Hominy feed,	11.10	10.47
15	Kelloggs & Miller,	Amsterdam,	Pure oil meal, O. P.	36.70	7.83
47	Kellogg, Spencer,	Buffalo,	Oil meal, O. P.	35.94	5.04
30	Kentucky Milling Co.,	Henderson, Ky.,	Jersey mixed feed,	11.59	3.48
51	Kidder, F. L., & Co.,	Paris, Ill.,	Hominy feed,	11.00	8.05
52	La Fayette Hominy Mill Co.,	La Fayette, Ind.,	Hominy feed,	11.50	7.63
75	Lederer, J., & Co.,	New Haven, Conn.,	Poultry food,	51.–55.	10.–16.
40	Mann Bros. & Co.,	Buffalo,	Oil meal,	35.15	7.05
62	Mapes, O. W.,	Middletown,	Mapes' balanced ration,	14.00	4.50
35	McCoy & Best,	Peekskill,	Evap. bone and meat meal,	41.40	19.75
7	Miami Maize Co.,	Toledo, O.	Hominy feed,	10.93	7.05
64	Mohawk Milling & Malting Co.,	Mohawk,	Corn and oat crop,	6.52	2.52
	Mohawk Milling & Malting Co.,	Mohawk,	Malt sprouts,	23.95	3.93
66–b	Mueller, E. P.,	Chicago, Ill.,	Dried brewers grains,	23.85	6.13
2	Muscatine Oat Meal Co.,	Muscatine, Ia.,	Friend's dairy food,	10.9	3.7
37	National Starch Mfg. Co.,	New York,	Gluten feed,	21.2	2.9
	National Starch Mfg. Co.,	New York,	King gluten meal,	32.6	3.7
38	Newport Milling Co.,	Newport, Ind.,	Hominy feed,	8.95	7.82
28	Oliver & Bolender,	Olean,	Chop feed,	8.13	4.59
54	Oliver, David,	Watertown,	Durham feed,	8.37	3.26
34	Oriental Flour Co.,	Danville,	Hominy feed,	11.06	9.85
11	Patent Cereals Co.,	Geneva,	Hominy chop,	11.64	8.03
25	Personius, D. V., & Sons,	Waverly,	Corn and oat feed,	7.94	4.18
58	Pfeffer Milling Co.,	Lebanon, Ill.,	Hominy feed,	10.0	8.0
23	Pope, Chas., Glucose Co.,	Chicago,	Corn bran,	9.19	4.65

23	Pope, Chas., Glucose Co.,	Chicago,	Cream gluten meal,	34.12	3.20
48	Preston Fertilizer Co.,	Brooklyn,	Champion poultry food,	40.0	8.0
42	Rathbun, Sawyer Co.,	Oneida,	Oneida chop feed,	10.5–13.5	3.0–4.5
71	Rauh, E., & Sons,	Indianapolis, Ind.,	Ideal stock food,	49.26	7.92
	Rauh, E., & Sons,	Indianapolis, Ind.,	Ideal poultry food,	48.39	7.70
76	Reynolds, Wm. T., & Co.,	Sioux City, Ia.,	Excelsior cooked feed,	7.7	4.1
44	Shellabarger Mill & Elevator Co.,	Decatur, Ill.,	Hominy meal,	10.76	8.64
77	Signal Mfg. Co.,	Despatch,	Signal cattle food,	26.–30.	2.0
57	Simpson Hendee & Co.,	New York,	Angola mixed feed,	16.61	5.48
74	Smith & Romaine,	Hackensack, N. J.,	Evap. boiled beef and bone,	45.0	15.0
19	Suffern Hunt & Co.,	Decatur, Ill.,	Hominy feed,	11.02	7.70
41	Staples, A. S.,	Rondout,	Arcade mixed feed,	10.42	5.86
61	Streeter, L. L., & Sons,	Johnstown,	Common feed,	8.78	5.23
9	U. S. Frumentum Co.,	Detroit, Mich.,	Frumentum hominy feed,	10.15	6.63
13	U. S. Sugar Refinery,	Waukegan, Ill.,	Waukegan gluten feed,	27.38	3.39
32	Victor Milling Co.,	Springville,	Golden chop,	9.17	5.84
67	Weidler, Sam. W., Co.,	Cincinnati, O.,	Hominy feed,	9.98	8.33
46	Wright, M. M., & Co.,	Danville, Ill.,	Hominy feed,	10.93	8.00

RESULTS OF INSPECTION.

During February and March of the present year a representative of the Station visited many towns in the dairy section of the State and sampled such feeding stuffs as he could find. Later while engaged in inspecting fertilizers he took such additional samples as came in his way. These have been analyzed and the results appear herewith.

TABLE II.—THE PROTEIN AND FAT FOUND IN SAMPLES OF

Collection No.	Manufacturer or jobber. Name.	Address.	Sampled at.
109	Chapin & Co.,	Buffalo,	Middletown.
64	The American Cotton Oil Co.,	New York, etc.,	Oxford.
24	[1] E. B. Williams & Co.,	Memphis, Tenn.,	Cortland.
31	[1] F. S. Walton & Co.,	Philadelphia, Pa.,	Binghamton.
69	[1] F. S. Walton & Co.,	Philadelphia, Pa.,	Norwich.
111	[1] Humphreys, Godwin & Co.,	Memphis, Tenn.,	Florida.
72	Kelloggs & Miller,	Amsterdam,	Hamilton.
74	Kelloggs & Miller,	Amsterdam,	Clinton.
33	American Linseed Co.,	New York, etc.,	Binghamton.
86	American Linseed Co.,	New York, etc.,	Watertown.
90	American Linseed Co.,	New York, etc.,	Pulaski.
50	Mann Bros. & Co.,	Buffalo,	Deposit.
78	Mann Bros. & Co.,	Buffalo,	Utica.
96	Mann Bros. & Co.,	Buffalo,	Phoenix.
81	Hauenstein & Co.,	Buffalo,	Boonville.
5	[3]		Homer.
60	[1] Cleveland Linseed Oil Co.,	Cleveland, O.,	Sidney.
87	[1,4] Douglas & Co.,	Cedar Rapids, Ia.,	Watertown.
88	[3,4]		Adams.
92	[1] W. J. Armstrong & Co.,	Milwaukee, Wis.,	Mexico.
	[1,2] Churchill & Co.,	Buffalo,	Holland Patent.
	[1,2] Churchill & Co.,	Buffalo,	Trenton.
	[1,2] Churchill & Co.,	Buffalo,	Mexico.
45	Glucose Sugar Refining Co.,	Chicago, Ill.,	Binghamton.
56	Chas. Pope Glucose Co.,	Chicago, Ill.,	Walton.
55	National Starch Mfg. Co.,	New York,	Hancock.
30	U. S. Sugar Refinery,	Waukegan, Ill.,	Binghamton.
80	U. S. Sugar Refinery,	Waukegan, Ill.,	Boonville.
4	Glucose Sugar Refining Co.,	Chicago, Ill.,	Homer.
7	Glucose Sugar Refining Co.,	Chicago, Ill.,	Homer.
71	Glucose Sugar Refining Co.,	Chicago, Ill.,	Hamilton.
1	Glucose Sugar Refining Co.,	Chicago, Ill.,	Tully.
13	Glucose Sugar Refining Co.,	Chicago, Ill.,	Cortland.
89	Glucose Sugar Refining Co.,	Chicago, Ill.,	Adams.
51	Glucose Sugar Refining Co.,	Chicago, Ill.,	Deposit.
54	[1] Thomas Keery,	Hancock,	Hancock.
117	[1] Empire Gluten Feed Co.,		Tully.
12	J. W. Barwell,	Waukegan, Ill.,	Cortland.
29	J. W. Barwell,	Waukegan, Ill.,	Marathon.
73	J. W. Barwell,	Waukegan, Ill.,	Hamilton.
105	T. W. Goeke & Co.,	St. Louis, Mo.,	Newburgh.
108	[1] Renolds & Co.,	Poughkeepsie,	Newburgh.

FEEDING STUFFS TAKEN DURING THE SPRING OF 1900.

Collection No.	Name of feed.	Protein. Found. Per ct.	Protein. Guaranteed Per ct.	Fat. Found. Per ct.	Fat. Guaranteed. Per ct.	Price per ton.
109	Cotton seed meal,	47.3	43.0	8.7	9.0	$25.00
64	Prime cotton seed meal,	42.4	43.0	9.9	9.0	27.00
24	Daisy " " "	46.6	43.0	9.1	9.0	27.00
31	Prime " " "	45.4	43.0	10.8	9.0	25.00
69	" " " "	47.0	43.0	10.4	9.0	28.00
111	Dixie brand cotton seed meal,	44.6	43.–48.	15.5	9.–11.	27.00
72	Pure oil meal,	35.3	36.70	8.5	7.83	32.00
74	" " "	34.8	36.70	8.4	7.83	32.00
33	" " " old process,	29.9	32.–36.	6.6	4.–7.	27.00
86	Old process oil meal,	29.6	32.–36.	8.8	4.–7.	29–32.
90	Pure ground oil cake,	35.3	32.–36.	8.4	4.–7.	33.00
50	Linseed oil meal, old process,	34.5	35.15	7.4	7.05	32.00
78	" " " " "	34.6	35.15	8.1	7.05	32.00
96	" " " " "	33.7	35.15	10.3	7.05	32.00
81	Pure old process oil meal,	35.6	39.62	7.4	8.53	35.00
5	" " " " "	32.0		7.7		31.00
60	Cleveland flax meal,	36.9	39.–41.	2.7	1.5–3.0	27.00
87	Old process oil meal,	29.5		7.1		30.00
88	Oil meal,	34.9		7.0		30.00
92	Oil meal, old process,	34.1		7.3		34.00
	Mayflower brand oil meal,	15.8	32.0	5.4	5.7	
	" " " "	16.7	32.0	5.6	5.7	
	" " " "	15.9	32.0	4.8	5.7	
45	Chicago gluten meal,	36.0	36.0	3.8	4.0	22.00
56	Cream " "	31.1	34.12	1.9	3.20	22.50
55	King " "	30.1	32.6	11.4	3.7	25.00
30	Waukegan gluten feed,	27.8	27.38	4.3	3.39	18.10
80	" " "	27.1	27.38	4.9	3.39	19.–20.
4	Buffalo gluten feed,	27.0	27.0	5.0	3.3	19.00
7	" " "	24.1	27.0	3.8	3.3	19.00
71	" " "	26.5	27.0	2.9	3.3	19.00
1	Rockford diamond gluten feed,	24.4	27.0	2.8	3.3	19.00
13	" " " "	25.9	27.0	3.1	3.3	18.00
89	" " " "	25.6	27.0	3.6	3.3	20.00
51	Davenport gluten feed,	25.6	27.0	4.3	3.3	18.00
54	Gluten feed,	26.4		4.6		20.00
117	" "	22.9		4.0		
12	Blatchford's calf meal,	25.1	27.12	6.1	6.80	60.00
29	" " "	24.8	27.12	5.4	6.80	70.00
73	" " "	24.3	27.12	5.1	6.80	70.00
105	Malt sprouts,	26.4	23.48	3.5	1.68	18.00
108	" "	25.5	24.8	2.2	1.7	18.00

TABLE II (*Continued*).

Collection No.	Manufacturer or jobber. Name.	Address.	Sampled at.
114	[1] Hollister, Chase & Co.,	New York,	Chester.
118	[1] India Wharf Brewing Co.,	Brooklyn,	Poughkeepsie.
38	The H. O. Company,	Buffalo,	Binghamton.
77	The H. O. Company,	Buffalo,	Utica.
36	The H. O. Company,	Buffalo,	Binghamton.
70	The H. O. Company,	Buffalo,	Hamilton.
75	The H. O. Company,	Buffalo,	Utica.
44	The American Cereal Co.,	Chicago,	Binghamton.
67	The American Cereal Co.,	Chicago,	Oxford.
85	The American Cereal Co.,	Chicago,	Carthage.
17	The American Cereal Co.,	Chicago,	Cortland.
100	The American Cereal Co.,	Chicago,	Geneva.
18	The American Cereal Co.,	Chicago,	Cortland.
20	The American Cereal Co.,	Chicago,	Cortland.
95	The American Cereal Co.,	Chicago,	Oswego.
98	Daisy Roller Mill,	Milwaukee, Wis.,	Phoenix.
59	Brooks Griffiths Co.,	Minneapolis, Minn.,	Downsville.
62	Brooks Griffiths Co.,	Minneapolis, Minn.,	Sidney.
8	Moon & Co.,	Binghamton,	Homer.
57	U. S. Flour Milling Co.,	Duluth, Minn.,	Walton.
83	W. S. Ankeny & Co.,	Minneapolis, Minn.,	Lowville.
84	Washburn, Crosby & Co.,	Minneapolis, Minn.,	Lowville.
25	Chapin & Co.,	Buffalo,	Cortland.
58	Hudnut Co.,	Terre Haute, Ind.,	Walton.
68	Hudnut Co.,	Terre Haute, Ind.,	Norwich.
15	Patent Cereals Co.,	Geneva,	Cortland.
99	Patent Cereals Co.,	Geneva,	Geneva.
28	Indianapolis Hominy Mills,	Indianapolis, Ind.,	Marathon.
112	Indianapolis Hominy Mills,	Indianapolis, Ind.,	Chester.
32	Suffern Hunt & Co.,	Decatur, Ill.,	Binghamton.
49	Shellabarger Mill & Elev. Co.,	Decatur, Ill.,	Deposit.
2	[6] Empire Grain & Elev. Co.,	Binghamton,	Tully.
10	[8]		Homer.
53	[7] Thomas Keery,	Hancock,	Hancock.
63	[8] M. F. Barringer,	Philadelphia, Pa.,	Oxford.
107	[1] Howell & Webster,	Middletown,	Newburgh.
26	Glucose Sugar Refining Co.,	Chicago, Ill.,	Cortland.
46	Glucose Sugar Refining Co.,	Chicago, Ill.,	Binghamton.
113	Chas. Pope Glucose Co.,	Chicago, Ill.,	Chester.
9	[8]		Homer.
82	[1] James A. Clark,	Buffalo,	Boonville.
48	The Kentucky Milling Co.,	Henderson, Ky.,	Deposit.
79	Andrew Cullen & Co.,	New York,	Utica.
65	Muscatine Oat Meal Co.,	Muscatine, Ia.	Oxford.
110	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Florida.

TABLE II (*Continued*).

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	
114	Dried brewers' grains,	25.1		9.0		$17.00
118	" " "	28.8	17.93	7.3	6.85	
38	H. O. Co.'s dairy feed,	17.9	18.0	4.0	4.5	22.50
77	" " " "	17.1	18.0	4.3	4.5	21.00
36	H. O. Co.'s horse feed,	11.9	12.0	4.1	4.5	22.00
70	" " " "	12.1	12.0	3.5	4.5	22.00
75	" " " "	12.0	12.0	3.9	4.5	20.00
44	Quaker dairy feed,	12.8	12.03	3.1	2.5	16.50
67	" " "	13.4	12.03	3.8	2.5	16.50
85	" " "	12.1	12.03	3.5	2.5	18.00
17	Schumacher's stock feed,	10.7	10.79	5.1	3.28	20.00
100	" " "	11.2	10.79	4.9	3.28	19.00
18	Buckeye wheat feed,	16.3	16.21	4.9	4.48	20.00
20	" " "	15.7	16.21	5.1	4.48	19.00
95	" " "	17.9	16.21	5.0	4.48	18.00
98	Daisy mixed feed,	16.9	16.94	5.3	4.6	18.00
59	Royal " "	16.4	16.61	5.6	5.48	21.50
62	" " "	17.1	16.61	5.9	5.48	19.00
8	Mixed bran and middlings,	16.4		5.7		19.00
57	Boston mixed feed,	16.2		5.8		19.50
83	Minnesota mixed feed,	17.4		5.5		15.50
84	Superior " "	16.3		5.3		19.00
25	Hominy feed,	11.1	11.0	9.7	8.0	16.00
58	" "	10.9	12.85	8.6	8.52	17.00
68	" "	11.3	12.85	10.6	8.52	18.00
15	" chop,	8.5	11.64	5.7	8.03	17.00
99	" "	11.4	11.64	9.5	8.03	15.50
28	" feed,	11.9	11.10	10.3	10.47	16.00
112	" "	11.8	11.10	11.1	10.47	15.60
32	" "	11.8	11.02	9.3	7.70	17.50
49	" meal,	10.9	10.76	8.5	8.64	17.00
2	" "	10.8	11.02	8.4	7.70	17.00
10	" "	10.4		8.0		17.00
53	" "	10.9		7.2		20.00
63	" " ivory brand,	11.4	11.10	9.2	10.47	16.00
107	" feed,	11.6		9.6		18.00
26	Sugar corn feed,	11.8	13.5	5.8	3.0	16.00
46	Fancy corn bran,	11.9	13.5	4.3	3.0	17.00
113	Corn bran,	8.2	.9.19	7.9	4.65	12.00
9	Sugar corn feed,	12.3		5.2		17.00
82	" " "	8.6		7.9		17.00
48	Jersey mixed feed,	12.6	11.59	4.4	3.48	18.00
79	Crescent oat feed,	7.8	11.0	3.5	7.35	16.00
65	Friends' concentrated dairy [food,	7.6	10.9	3.4	3.7	14.00
110	Cerealine feed No. 1,	9.5	9.0	6.8	5.82	18.00

TABLE II (*Continued*).

Collection No.	Manufacturer or jobber.		Sample at
	Name.	Address.	
47	Cerealine Mfg. Co.,	Indianapolis, Ind.,	Deposit.
19	Diamond Mills,	Buffalo,	Cortland.
93	Diamond Mills,	Buffalo,	Oswego.
6	Husted Milling & Elev. Co.,	Buffalo,	Homer.
43	H. R. Heath & Sons,	Fort Dodge, Va.,	Binghamton.
104	M. L. Crittenden,	Buffalo,	Hudson.
106	David Oliver,	Watertown,	Newburgh.
61	Edw. Elsworth & Co.,	Buffalo,	Sidney.
66	Akron Cereal Co.,	Akron, O.,	Oxford.
3	The American Cereal Co.,	Chicago, Ill.,	Tully.
14	The American Cereal Co.,	Chicago, Ill.,	Cortland.
35	The American Cereal Co.,	Chicago, Ill.,	Binghamton.
97	The American Cereal Co.,	Chicago, Ill.,	Phoenix.
34	Akron Cereal Co.,	Akron, O.,	Binghamton.
52	D. V. Personius & Son,	Waverly,	Hancock.
115	Wm. T. Reynolds & Co.,	Sioux City, Ia.,	Poughkeepsie.
42	The American Cereal Co.,	Chicago, Ill.,	Binghamton.
11	[3]		Homer.
91	[4] Chapin & Co.,	Buffalo,	Mexico.
101	[4] Akron Cereal Co.,	Akron, O.,	Geneva.
94	[1] F. K. Fish & Sons,	N. Y., 2-4 Stone St.,	Oswego.
103	[1,4] C. H. Reeve,	New York,	Southampton.
102	[1,4] C. H. Reeve,	New York,	Southampton.
76	The H. O. Co.,	Buffalo,	Utica.
37	L. R. Wallace,	Middletown,	Binghamton.
16	The American Cereal Co.,	Chicago, Ill.,	Cortland.
21	The American Cereal Co.,	Chicago, Ill.,	Cortland.
39	[1] Geo. L. Harding,	Binghamton,	Binghamton.
22	Smith & Romaine,	N. Y., 329 Wash. St.,	Cortland.
116	Bowker Fertilizer Co.,	New York & Boston,	Poughkeepsie.
27	[1] Chas. F. Saul,	Syracuse,	Marathon.
23	[6] Chas. F. Saul,	Syracuse,	Cortland.
40	[1] Geo. L. Harding,	Binghamton,	Binghamton.
41	[1] Geo. L. Harding,	Binghamton,	Binghamton.

[1] Not licensed in this State.
[2] Mfg. at Mayflower Mills, Fort Wayne, Ind.
[3] Manufacturer not known.
[4] Bought before law went into effect.
[6] From Suffern Hunt & Co., Decatur, Ill.

TABLE II (*Continued*).

Collection No.	Name of feed.	Protein. Found. Per ct.	Protein. Guaranteed. Per ct.	Fat. Found. Per ct.	Fat. Guaranteed Per ct.	Price per ton.
47	Cerealine feed No. 2,	11.5	10.31	9.6	8.62	$17.00
19	Corn and oat feed,	8.1	9.44	2.2	4.78	18.00
93	" " "	7.3	9.44	1.6	4.78	18.00
6	Monarch chop feed,	7.1	9.19	3.1	3.45	18.00
43	Yankee corn and oat feed,	8.3	8.96	3.3	4.33	15.50
104	Sterling provender,	7.9	8.82	3.4	5.55	18.00
106	Durham corn and oat feed,	6.8	8.37	2.8	3.26	19.00
61	De-Fi corn and oat feed,	8.3	8.30	3.0	3.00	17.00
66	Royal oat feed,	5.1	8.25	2.5	4.14	16.00
3	Victor corn and oats,	7.1	8.23	2.9	3.0	16.00
14	" " " "	7.9	8.23	3.8	3.0	17.00
35	" " " "	8.5	8.23	3.8	3.0	16.00
97	" " " "	8.7	8.23	4.6	3.0	17.00
34	No. 1 chop feed,	9.3	7.94	6.4	4.18	17.00
52	Corn and oat feed,	8.6	7.94	1.6	4.18	17.00
115	Excelsior cooked feed,	10.8	7.7	6.5	4.1	20.00
42	Vim oat feed,	6.8	6.3	3.1	2.58	14.00
11	Quaker oat feed,	5.0		2.4		16.00
91	Corn and oat chop,	7.8		3.4		18.00
101	Corn and oats,	8.4		4.0		18.00
94	Oat feed,	3.0		1.4		15.00
103	Dairy feed,	13.8		4.9		22.00
102	Rice meal,	14.5		15.5		20.00
76	H. O. poultry feed,	17.0	17.0	5.6	5.5	30.00
37	Mapes balanced ration,	13.2	14.0	4.1	4.5	30.00
16	American poultry food,	11.3	13.65	5.6	3.96	25.00
21	" " "	13.4	13.65	6.1	3.96	25.00
39	Harding's famous clover com.	13.4	13.75	5.0	5.50	35.00
22	Boiled beef and bone,	42.3	45.0	17.5	15.0	45.00
116	Bone meal,	34.0	30.0	2.2	5.0	
27	Chicken food,	48.1	50.68	12.3	12.3	50.00
23	Beef scrap,	46.4	45.–51.	18.4	15.–22.	60.00
40	Harding's beef scrap,	43.0	40.–42.	25.9	32.–38.	40.00
41	" meat meal,	47.2		13.8		40.00

[6] Mfg. and licensed by H. Finn & Sons, Syracuse, N. Y.
[7] Sold by Empire Grain & Elev. Co., Binghamton, N. Y.
[8] Sold by Indianapolis Hominy Mills, Ind.
[9] Guarantee based upon water-free sample.

COMMENTS.

In commenting on the result of the inspection so far conducted, the first fact to attract attention is the presence of some goods in the market, at the time the samples were taken, in apparant violation of the law. These cases are explained in a variety of ways, such as the shipping of the goods into the market before the law went into effect, a change in the name of the brand, the refusal of the manufacturer or jobber doing business in another state to pay the license fee, thus throwing the responsibility on the dealers, ignorance of the law and other reasons less valid. These cases are receiving attention and the inevitable result will be either finally to bring the offending parties into line with legal requirements or drive their goods out of the markets of this state. In the meantime dealers are warned not to handle the goods herein marked as illegally sold, no matter how high their quality, until clear proof is furnished that the provisions of the law have been fully met. There are so many brands of feeding stuffs of high quality which may be dealt in legally that it is not necessary to assume any risks in order to meet the demands of all consumers.

It is very noticeable that a considerable proportion of the samples fall short of the guarantee in protein and not a few in fat. The percentage deficient in protein is 50 and in fat 30. In most of these cases, however, the actual composition falls below the guarantee no more than might be expected from the natural variations in composition. Additional samples must be taken in order to determine the general composition of the several brands.

A notable instance of fraudulent marking of an unlicensed feeding stuff is the Mayflower Brand Oil Meal, guaranteed to contain 32 per ct. of protein, and actually containing about half that proportion.

One company reports the analyses of its goods on the basis of what they would contain if water-free. As feeding stuffs are never found in the market in a water-free condition, but seldom hold less than 8 or 10 per ct. of water, such figures are deceptive

as relating to actual composition. If, for instance, a feeding stuff carries 27 per ct. of protein when water-free, it will scarcely contain over 25 per ct. in the air-dry condition as found in the market and generally less.

LAWS OF NEW YORK.

Chapter 338, Laws of 1893, Article 9, as Created by Chapter 510, Laws of 1899, and Amended by Chapter 79, Laws of 1900.

ARTICLE NINE.

SALE AND ANALYSIS OF CONCENTRATED COMMERCIAL FEEDING STUFFS.

Section 120. Term "concentrated commercial feeding stuffs" defined.
121. Statements to be attached to packages; contents; analysis.
122. Statements to be filed with director of agricultural experiment station; to be accompanied by sample.
123. License fee.
124. Analysis to be made by director of experiment station; samples to be taken for analysis.
125. Penalty for violation of article.
126. Sale of adulterated meal or ground grains; penalty.
127. Violation to be reported to the commissioner of agriculture.

§ 120. Term "Concentrated Commercial Feeding Stuffs" Defined.—The term "concentrated commercial feeding stuffs" as used in this article, shall include linseed meals, cotton seed meals, pea-meals, cocoanut meals, gluten meals, gluten feeds, maize feeds, starch feeds, sugar feeds, dried brewer's grains, malt sprouts, hominy feeds, cerealine feeds, rice meals, oat feeds, corn

and oat chops, ground beef or fish scraps, mixed feeds, and all other materials of similar nature; but shall not include hays and straws, the whole seeds nor the unmixed meals made directly from the entire grains of wheat, rye, barley, oats, Indian corn, buckwheat, and broom corn. Neither shall it include wheat, rye and buckwheat brans or middlings, not mixed with other substances, but sold separately, as distinct articles of commerce, nor pure grains ground together.

§ 121. STATEMENTS TO BE ATTACHED TO PACKAGES; CONTENTS; ANALYSIS.—Every manufacturer, company or person who shall sell, offer or expose for sale or for distribution in this state any concentrated commercial feeding stuff, used for feeding farm live stock, shall furnish with each car or other amount shipped in bulk and shall affix to every package of such feeding stuff in a conspicuous place on the outside thereof, a plainly printed statement clearly and truly certifying the number of net pounds in the package sold or offered for sale, the name or trade mark under which the article is sold, the name of the manufacturer or shipper, the place of manufacture, the place of business and a chemical analysis stating the percentages it contains of crude protein, allowing one per centum of nitrogen to equal six and one-fourth per centum of protein, and of crude fat, both constituents to be determined by the methods prescribed by the director of the New York Agricultural Experiment Station. Whenever any feeding stuff is sold at retail in bulk or in packages belonging to the purchaser, the agent or dealer, upon request of the purchaser, shall furnish to him the certified statement named in this section.

§ 122. STATEMENTS TO BE FILED WITH DIRECTOR OF AGRICULTURAL EXPERIMENT STATION; TO BE ACCOMPANIED BY SAMPLE.—Before any manufacturer, company or person shall sell, offer or expose for sale in this state any concentrated commercial feeding stuffs, he or they shall for each and every feeding stuff bearing a distinguishing name or trade mark, file annually during the month of December with the director of the New York Agricultural Experiment Station a certified copy of the statement

specified in the preceding section, said certified copy to be accompanied, when the director shall so request, by a sealed glass jar or bottle containing at least one pound of the feeding stuff to be sold or offered for sale, and the company or person furnishing said sample shall thereupon make affidavit that said sample corresponds within reasonable limits to the feeding stuff which it represents, in the percentage of protein and fat which it contains.

§ 123. License Fee.—Each manufacturer, importer, agent or seller of any concentrated commercial feeding stuffs, shall pay annually during the month of December to the treasurer of the New York Agricultural Experiment Station a license fee of twenty-five dollars for each and every brand sold or offered for sale. Whenever a manufacturer, importer, agent or seller of concentrated commercial and feeding stuffs desires at any time to sell such material and has not paid the license fee therefor in the preceding month of December, as required by this section, he shall pay the license fee prescribed herein before making any such sale. The amount of license fees received by such treasurer pursuant to the provisions of this section shall be paid by him to the treasurer of the state of New York. The treasurer of the state of New York shall pay from such amount when duly appropriated the moneys required for the expense incurred in making such inspection required by this section and enforcing the provisions thereof. The board of control of the New York Agricultural Experiment Station shall report annually to the legislature the amount received pursuant to this article, and the expense incurred for salaries, laboratory expenses, chemical supplies, traveling expenses, printing and other necessary matters. Whenever the manufacturer, importer or shipper of concentrated commercial feeding stuffs shall have filed the statement required by section one hundred and twenty-one of this article and paid the license fee as prescribed in this section, no agent or seller of such manufacturer, importer or shipper shall be required to file such statement or pay such fee.

§ 124. Analysis to be Made by Director of Experiment Station; Samples to be Taken for Analysis.—The director of

the New York experiment station shall annually analyze, or cause to be analyzed, at least one sample to be taken in the manner hereinafter prescribed, of every concentrated commercial feeding stuff sold or offered for sale under the provisions of this act. Said director shall cause a sample to be taken, not exceeding two pounds in weight, for said analysis, from any lot or package of such commercial feeding stuff which may be in the possession of any manufacturer, importer, agent or dealer in this state; but said sample shall be drawn in the presence of the parties in interest, or their representatives and taken from a parcel or a number of packages, which shall not be less than ten per centum of the whole lot sampled, and shall be thoroughly mixed, and then divided into equal samples, and placed in glass vessels, and carefully sealed and a label placed on each, stating the name of the party from whose stock the sample was drawn and the time and place of drawing, and said label shall also be signed by the person taking the sample, and by the party or parties in interest or their representative at the drawing and sealing of said samples; one of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled; and the sample or samples retained by the director shall be for comparison with the certified statement named in section one hundred and twenty-two of this article. The result of the analysis of the sample or samples so procured, together with such additional information as circumstances advise, shall be published in reports or bulletins from time to time.

§ 125. PENALTY FOR VIOLATION OF ARTICLE.—Any manufacturer, importer, or person who shall sell, offer or expose for sale or for distribution in this state any concentrated commercial feeding stuff, without complying with the requirements of this article, or any feeding stuff which contains substantially a smaller percentage of constituents that are certified to be contained, shall, on conviction in a court of competent jurisdiction, be fined not more than one hundred dollars for the first offense, and not more than two hundred dollars for each subsequent offense.

§ 126. ADULTERATED MEAL OR GROUND GRAIN; PENALTY.—Any person who shall adulterate any kind of meal or ground grain with milling or manufacturing offals, or any other substance whatever, for the purpose of sale, unless the true composition, mixture or adulteration thereof is plainly marked or indicated upon the package containing the same or in which it is offered for sale; or any person who knowingly sells, or offers for sale any meal or ground grain which has been so adulterated unless the true composition, mixture or adulteration is plainly marked or indicated upon the package containing the same, or in which it is offered for sale, shall be fined not less than twenty-five or more than one hundred dollars for each offense.

§ 127. VIOLATION TO BE REPORTED TO THE COMMISSIONER OF AGRICULTURE.—Whenever the director becomes cognizant of the violation of any of the provisions of this article, he shall report such violation to the commissioner of agriculture, and said commissioner of agriculture shall prosecute the party or parties thus reported; but it shall be the duty of said commissioner upon thus ascertaining any violation of this article, to forthwith notify the manufacturer, importer or dealer in writing and give him not less than thirty days thereafter in which to comply with the requirements of this article, but there shall be no prosecution in relation to the quality of any concentrated commercial feeding stuff if the same shall be found substantially equivalent to the certified statement named in section one hundred and twenty-two of this article.

§ 1. This act shall take effect December first, eighteen hundred and ninety-nine.

REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR THE SPRING AND FALL OF 1900.*

L. L. VanSlyke and W. H. Andrews.

SUMMARY.

(1) Samples collected. During the year 1900 the Station collected 638 samples of commercial fertilizers, representing 450 different brands. Of these different brands 326 were complete fertilizers; of the others, 48 contained phosphoric acid and potash without nitrogen; 20 contained nitrogen and phosphoric acid without potash; 10 contained nitrogen only; 37 contained phosphoric acid alone, and 9 contained potash salts only.

(2) Nitrogen. The 326 brands of complete fertilizers contained nitrogen varying in amount from 0.44 to 8.15 per ct., and averaging 2.16 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.10 per ct., the guaranteed average being 2.06 per ct., and the average found being 2.16 per ct.

In 235 brands of complete fertilizers the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 2.02 per ct., and averaging 0.22 per ct.

In 91 brands the nitrogen was below the guaranteed amount, the deficiency varying from 0.01 to 1.98 per ct., and averaging 0.21 per ct. In 83 cases, the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0 to 7.10 per ct. and averaged 0.89 per ct.

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*Partial reprint of Bulletin No. 177.

(3) Available phosphoric acid. The 326 brands of complete fertilizers contained available phosphoric acid varying in amount from 1.20 to 17.47 per ct. and averaging 8.90 per ct. The average amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 1.28 per ct., the guaranteed average being 7.62 per ct. and the average found being 8.90 per ct.

In 301 brands of complete fertilizers the amount of available phosphoric acid found was equal to or above the amount guaranteed, the excess varying from 0.02 to 10.80 per ct. and averaging 1.46 per ct.

In 25 brands the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.02 to 5.32 per ct. and averaging 1.03 per ct. In 14 cases the deficiency was below 0.5 per ct.

The amount of water-soluble phosphoric acid varied from 0 to 9.95 per ct. and averaged 5.52 per ct.

(4) Potash. The complete fertilizers contained potash varying in amount from 0.27 to 12.00 per ct., and averaging 4.84 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.41 per ct., the guaranteed average being 4.43 per cent., and the average found being 4.84 per ct.

In 250 brands of complete fertilizers, the amount of potash found was equal to or above the guaranteed amount, the excess varying from 0.01 to 6.49 per ct. and averaging 0.65 per ct.

In 76 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 2.21 per ct. and averaging 0.43 per ct. In 56 of these cases, the deficiency was less than 0.5 per ct.

In 64 cases among the 326 brands of complete fertilizers the potash was contained in the form of sulphate free from an excess of chlorides.

(5) The retail selling price of the complete fertilizers varied from $15 to $60 a ton and averaged $27.27. The retail cost of the separate ingredients unmixed averaged $19.72, or $7.55 less than the selling price.

INTRODUCTION.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the year 1900, the Station's collecting agents visited 138 towns between April 5 and October 1, obtaining 638 samples of commercial fertilizers. These samples represent 450 different brands, the product of 92 different manufacturers, each manufacturer being represented by from one to 28 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

CLASSES OF FERTILIZERS COLLECTED.

Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing phosphoric acid and potash without nitrogen.	Brands of complete fertilizers.
10	37	9	20	48	326

COMPOSITION OF FERTILIZERS COLLECTED.

The following tabulated statement shows the average composition of the complete fertilizers collected during the year, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	Per ct. guaranteed			Per ct. found.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average.	Lowest.	Highest.	average.	
Nitrogen	0.39	8.25	2.06	0.44	8.15	2.16	0.10
Available phosphoric acid....	0.63	12.00	7.62	1.20	17.47	8.90	1.28
Insoluble phosphoris acid....	——	——	——	0.00	13.20	2.50	——
Potash	1.00	11.00	4.43	0.27	12.00	4.84	0.41
Water-soluble nitrogen	——	——	——	0.00	7.10	0.89	——
Water-soluble phosphoric acid	——	——	——	0.00	9.95	5.52	——

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials*, could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March plus about 20 per ct. in case of goods for which there are wholesale quotations.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1900. Cts. per pound.
Nitrogen in ammonia salts	17
" in nitrates	13½
Organic nitrogen in dry and fine-ground fish, meat and blood, and mixed fertilizers	15½
" in fine-ground bone and tankage	15½
" in coarse bone and tankage	10½
Phosphoric acid, water-soluble	4½
" citrate-soluble	4
" in fine-ground fish, bone and tankage	4
" in coarse fish, bone and tankage	3
" in mixed fertilizers, insoluble in ammonium citrate and water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 15½ cents a pound for nitrogen, 4½ cents a pound for water-soluble phosphoric acid, 4 cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble

phosphoric acid, and 4¼ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual selling price of the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following tables:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial valuation of complete fertilizers.	Selling price of one ton of complete fertilizer.			Average increased cost of mixed materials over unmixed materials for one ton.
Average	Lowest.	Highest.	Average.	
$19.72	$15	$60	$27.27	$7.55

COST OF ONE POUND OF PLANT FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	21.4 cents.
Phosphoric acid (available)	6.2 cents.
Potash	6.2 cents.

NEW FERTILIZER LAW.

The State legislature amended the fertilizer law in 1899 and attention is called to the principal changes that affect manufacturers and dealers.

(1) All fertilizers selling for *five* dollars or more per ton will come under the law, the limit previously having been confined to fertilizers seling for *ten* dollars or more per ton.

(2) Every manufacturer, importer, dealer or agent must pay

a license fee amounting to *twenty* dollars a year for each separate brand or kind of fertilizer or fertilizing material.

(3) Statements of guarantee analysis, etc., are to be filed and license fees paid *during December* each year covering the goods to be sold during the year following.

[The detailed analyses of the samples collected are not reprinted in this report; as they cease to have value before the report is printed and distributed.—Director.]

INSPECTION OF BABCOCK MILK TEST BOTTLES.*

W. H. Jordan and G. A. Smith.

When Dr. Babcock first announced the test which bears his name its accuracy was questioned. So many methods for determining the amount of fat in a given sample of milk had been found lacking in rapidity or in correctness that many who had a knowledge of such work were inclined to doubt the certainity of correct results in any method so simple and so rapid as the Babcock test; but as its workings have become better understood that feeling has been largely overcome and at the present time very few question its reliability if properly handled by a careful operator, who uses correctly calibrated glassware and acid of proper strength. As the use of this method has become more general as a means of apportioning the value of milk delivered at the butter and cheese factories by the individual farmer, there has come to be a quite general understanding that everything must be properly done in order to give each produced his due share. In some instances the use of the test has been discontinued on account of a lack of faith in the methods practiced by the operator. This lack of confidence has been increasing rather than diminishing and it has been felt by those interested that some plan should be devised whereby this feeling could be overcome and a very general use of the Babcock test in butter and cheese factories promoted.

Last winter in an amendment to the agricultural law, Chapter 544, one of the provisions added was that: "Whenever manufacturers of butter and cheese purchase milk upon the basis of

*Reprint of Bulletin No. 178.

the amount of fat contained therein and use for ascertaining the amount of such fat what is known as the Babcock test, the bottles used in such test shall before such use be examined by the director of the New York Experiment Station at Geneva. If such bottles are found to be properly constructed and graduated so as to accurately show the amount of fat contained in milk, each of them shall be legibly and indelibly marked S. B."

The director of the station knew nothing of the passage of this law until some time after it was placed on the statute books and for that reason was not prepared to comply with its provisions as soon, nor to the extent desirable in a law of that class. Before we were able to get a marking device perfected that would comply with the provisions of the law, some bottles came with the request that they be returned at an early date. In order to accommodate these first applicants we resorted to the use of a copper tag with S. B. stamped on that and returned the tested bottles with the understanding that we should, as soon as we could, recall those bottles and properly mark them. Some of those bottles have been returned but the others are still out and should be returned and legally marked. We use for that purpose an air pressure sand blast and a stencil with the letters S. B. cut in it.

The law as now worded is a step in the right direction, but other provisions should be added in order to cover the whole ground in such a way that there can be no misunderstanding of the requirements. The inspection should cover all Babcock bottles used to determine the per ct. of fat in the milk, whether the milk is purchased outright or divided on a coöperative plan. The pipette and all other glassware as well as the bottles should be tested and marked. The use of mutilated or falsified glassware should be forbidden under penalty severe enough to deter the shrewd maker from breaking off the tip of the pipette or similar dishonest practices in order to show a small percentage of fat and consequent large overrun of butter. This fraudulent manipulation of the test is one of the factors which has tended to give the impression that the system is not correct. A farmer

takes his milk to the factory and it contains, by test, a certain amount of fat. On this basis he receives a given price per hundred for his milk, this price being fixed by the returns from the butter sold. When he meets his neighbor who patronizes an adjoining factory and whose milk tests the same as his and whose butter is sold at the same price, but who gets more per hundred for the milk, he condemns the test; when the trouble is not in the method but in the way it is handled. A competent, honest man with clean, correctly graduated glassware, will give uniform results and we must have that combination to make the Babcock fat test uniformly acceptable.

Some states require the operators of the Babcock test to pass an examination to determine whether they have sufficient knowledge of its workings to make a correct test. This is a proper safeguard but it lacks in one particular, that it does not tell whether the applicant for a position is an honest man, which is quite as necessary as that he be intelligent enough to operate the machine. In order to have the work of the Babcock test perfectly satisfactory it may be necessary for the State to have careful inspection made at factories and creameries to know that the work is done in an honest, careful way.

The method followed at the Station in testing the bottles is as follows: A graduated burette, which has been carefully tested beforehand to insure its accuracy and uniformity at all points of the scale, is filled with cleaned, dried mercury. If the bottle to be tested has been used it is first thoroughly cleansed and dried; but this is omitted with new, clean bottles. The bottle is then placed under the burette and filled with mercury, first rapidly to the o mark, then slowly, with repeated comparison with the burette scale, to the top of the scale on the bottle. If the filling does not show any irregularity in the neck of the bottle, and if the variation is not over $\frac{1}{10}$ of one per ct. in the length of the 10 per ct. graduation of the bottle, it is passed as correct, as the variation in the ordinary sample of milk would be so small that it would be imposible to detect it. If the variation is $\frac{2}{10}$ of 1 per ct. or over, the bottle is rejected and destroyed. The

law did not call for the examination of the pipettes and only a few were sent. Those that came were examined, and, as a rule, found correct.

The whole number of bottles examined was 2259. There were rejected from that number 76 bottles. The new bottles were, as a rule, fairly correct, the largest variation being in bottles made in the early history of the test. Some bottles of that character showed a variation of nearly 1 per ct. from the burette scale.

Following is a list of creameries and individuals who have complied with the law and sent their bottles for examination.

LIST OF PARTIES SENDING BABCOCK TEST BOTTLES FOR EXAMINATION.

Name.	Address.	Number bottles tested.	Number bottles rejected.
Beechnut Creamery Co.,	Leroy,	107	3
Bell Bros.,	Winthrop,	12	
Beswick, Jas. E.,	Morley,	24	[1]1
Boomhower, A. D.,	Plattsburgh,	24	
Boyd, D. E.,	Downsville,	28	3
Boynton, W. R.,	Norwood,	{ 57 59	
Burch & Baldwin,	Westville	16	
Burr, W. B.,	Bangor,	{ 26 24	2
[2]Burrell, D. H.	Little Falls,	288	2
Canisteo Creamery Co.,	Canisteo,	40	
Champion Milk Color Co.,	Cortland.	36	1
Clifton Springs Sanitarium,	Clifton Springs,	31	
Clyde Creamery Co.,	Clyde,	50	3
Cohocton Creamery Co.,	Cohocton,	14	6
Cole & Fish,	Willink,	48	8
Converse, H. J.,	Potsdam,	11	
Cook, A. & H. E.,	Denmark,	23	1
Davenport Creamery,	Davenport,	23	1
Delavan Creamery Co.,	Delavan,	{ 48 43	1 1
Dickinson, W. S.,	Madrid,	36	1
DeRuyter Creamery Co.,	DeRuyter,	28	1
Etna Creamery Co.	Etna,	51	1
Fayetteville Creamery Co.,	Fayetteville,	30	
Fisher Bros.,	Madrid,	23	
Gilt Edge Creamery Co.,	North Lisbon,	34	

[1]Hole in side. [2]From E. Greiner.

Name.	Address.	Number bottles tested.	Number bottles rejected.
Hall, D.,	West Windsor,	28	
Hemman, A. J.,	Madrid,	24	
Hilton Creamery Co.,	Hilton,	37	1
		22	1
Hudson Valley Creamery Co.,	Deposit,	24	
Humphrey & Co.,	Churubusco,	36	
Ideal Creamery,	Libson Center,	22	
Ingersoll, E. M.,	Lacona,	46	4
Jeffersonville Creamery Co.,	Jeffersonville,	18	
Martin, L. B.,	Pierrepont Manor,	18	2
[3]Mather Bros.,	Belleville,		
Middlemass, W. M.,	Madrid,	27	1
Overton & Co.,	Belleville,	40	2
Peet, R. G.,	Oneonta,	12	
Pollock, A. X.,	North Lawrence,	34	
Reynolds & Chase,	Brainardville,	13	
		50	
Root, C. P.,	Gilbertsville,	23	1
	West Laurens,	36	1
Rutherford, Thos. F.,	Chipman,	24	
Seaver, D. B.,	Stockholm Center,	25	
Sennett Creamery,	Sennett,	60	2
		58	2
Smith, G. A.,	West Stockholm.	17	3
Sodus Creamery Co.,	Sodus,	60	6
Solsville Creamery Co.,	Solsville,	15	5
Speer, J. O.,	Lisbon Center,	36	
Straight, E. C.,	Cassadaga,	40	3
Trombly Bros.,	Altona,	24	
Tucker, E. B.,	Hannibal,	48	2
Wadsworth & Co.,	Knapps,	24	4
Wilson, W. F.,	Louisville,	72	1
Wood, N., & Son,	Pierrepont Manor,	12	
		2259	76

[3]Record mislaid.

REPORT OF ANALYSES OF PARIS GREEN AND OTHER INSECTICIDES IN 1900.*†

L. L. VanSlyke and W. H. Andrews.

SUMMARY.

In accordance with the provisions of a law designed to protect purchasers of Paris green, samples were secured during 1900 and the results are published in this bulletin.

Paris green contains as its chief constituent a compound called copper aceto-arsenite, which, when chemically pure contains:

Arsenious oxide	58.64 per ct.
Copper oxide,	31.30 "
Acetic acid,	10.06 "

In the 22 samples of Paris green examined, the arsenious oxide varied from 55.83 to 60.80 per ct. and averaged 57.05 per ct. The water-soluble arsenious oxide varied from 0.61 to 15.69 per ct. and averaged 1.68 per ct.

The copper oxide varied from 27.22 to 31.20 per ct. and averaged 30.02 per ct. The amount of arsenious oxide for each pound of copper oxide varied from 1.81 to 2.24 and averaged 1.89 pounds. The impurity most commonly found was white arsenic and this did not appear to be excessive. The general result of the examination is to show a good quality of Paris green in the market at the time the samples were taken.

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†Reprint of Bulletin No. 190.

There are given in addition, analyses of Arsenoid, Paragrene, Black Death, Bug Death, and Hammond's Slug Shot.

INTRODUCTION.

During the year 1900, there were collected for analysis twenty-two samples of materials sold as Paris green, and also one sample each of Arsenoid, Paragrene, Black Death, Bug Death and Hammond's Slug Shot. Of the twenty-two samples of Paris green analyzed, ten represent firms whose goods were not examined by us in 1899.

CHEMICAL COMPOSITION OF PARIS GREEN.

Paris green, or copper aceto-arsenite, may be regarded, when chemically pure, as containing approximately

Copper arsenite	82	per ct.
Copper acetate	18	"

However, it is customary, when speaking of the amount of arsenic contained in Paris green, to refer to it as arsenious oxide, and similarly the amount of copper is referred to as copper oxide. Arsenious oxide, as such, and copper oxide, as such, are not present in pure Paris green, and the use of these terms in giving the results of chemical analysis is simply a convenient custom. Using the usual form of expression, as thus explained, we should give the composition of pure copper aceto- arsenite as follows:

Arsenious oxide	58.64	per ct.
Copper oxide	31.30	"
Acetic acid	10.06	"

When we say that this compound in pure form contains 58.64 per ct. of arsenious oxide, we mean that the amount of arsenic present simply is equivalent to the quantity of arsenious oxide stated, and not that arsenious oxide is present to that or any other extent in the compound known as copper aceto-arsenite.

Now, Paris green, as found in the market, rarely, if ever, consists entirely of pure copper aceto-arsenite, but contains this

compound as its chief constituent, with varying proportions of other substitutes. The varying composition of Paris green is usually due to variations in care given to the details of the process of manufacture.

Methods of chemical analysis.—The total arsenic was determined by the method proposed by Thorn Smith (*Jour. Am. Chem. Soc.*, 21 : 769) as modified by J. K. Haywood (same journal, 22 : 576). In determining the water-soluble arsenic, J. K. Haywood's method was used (*Jour. Am. Chem. Soc.*, 22 : 578), except that the Paris green was treated twenty-four hours for extraction at the rate of one part by weight of Paris green to 1,000 parts of distilled water. The copper was determined by electrolysis.

ANALYSIS OF SAMPLES OF PARIS GREEN.

Sample number.	Name of manufacturer.	Total arsenious oxide.	Water-soluble arsenious oxide.	Copper oxide.	Crystals of arsenious oxide present as shown by microscopic examination.	Solubility in strong ammonia.	Retail price per pound.
		Per ct.	Per ct.	Per ct.			Cents.
105	Acme Color Works	56.56	1.35	30.20	Very few	Complete	25
43	Acme Color Works	56.50	1.10	29.89	Few	Complete	25
52	Adler Color and Chemical Works	56.25	1.59	29.85	Few	Nearly complete in 24 hours	25
101	Adler Color and Chemical Works	56.75	1.23	30.54	Few	Nearly complete in 24 hours	20
40	A. B. Ansbacher & Co	56.81	0.61	30.33	Very few	Complete	25
104	A. B. Ansbacher & Co	56.75	1.10	29.98	Few	Complete	30
50	James A. Blanchard	59.20	15.69	6.86	Much foreign matter	Slightly	30
41	James A. Blanchard	58.16	0.74	28.53	None	Incomplete in 24 hours	25
45	Cawley, Clark & Co	56.62	0.74	31.20	Numerous	Complete	40
35	Chas. M. Childs & Co	57.17	0.74	30.33	Few	Complete in 24 hours	18
49	Eckstein Bros	57.11	1.10	28.76	Few	Complete in 24 hours	25
51	M. Herrmann & Co	56.62	1.23	30.16	Few	Complete	25
47	Highland Chemical Co	57.11	0.98	30.39	Few	Complete	30
37	Fred L. Lavanburg	56.50	0.86	30.16	Few	Complete	20
48	Leggett & Bros	56.93	1.10	30.39	Few	Complete in 24 hours	25
42	N. Y. Enamel Paint Co	56.75	1.59	29.45	Very few	Complete	25
36	John C. Lucas	55.83	0.98	30.73	None	Complete	25
34	I. Pfeiffer	56.75	0.74	30.16	Very few	Complete	22
33	C. T. Reynolds & Co	60.80	0.98	27.22	Few	Complete	22
102	C. T. Reynolds & Co	57.05	0.86	30.70	Few	Complete	20
103	C. T. Reynolds & Co	56.75	0.86	30.39	Numerous	Complete	20
44	Not given	56.17	0.86	30.23	None	Complete	25

DISCUSSION OF RESULTS OF CHEMICAL ANALYSIS.

1. *Total arsenious oxide.*—In the 22 samples of materials sold as Paris green, examined by us, the amount of arsenic, equivalent to arsenious oxide, varies from 55.83 to 60.80 per ct., and averages 57.05 per ct. This average is about one-half of one per ct. higher than that found last year, and is about one and one-half per ct. below the equivalent of arsenious oxide contained in pure copper aceto-arsenite. So far as the total arsenic content is concerned, the amount found indicates a high quality of Paris green. The variation is about the same as last year and, excepting two samples, is within surprisingly narrow limits. The lowest amount of arsenious oxide is nearly six per ct. above that required by law, viz.: 50 per ct. Were the total amount of arsenic present in Paris green the only point to be considered, the quality would be regarded as very satisfactory, but we must consider at the same time the amount of water-soluble compounds of arsenic present in Paris green.

2. *Water-soluble compounds of arsenic.*—The presence of water-soluble arsenic in Paris green is seriously objectionable, owing to the fact that soluble arsenic compounds injure foliage. Hilgard, of California, states that in the dry climate of California Paris green injures foliage when it contains an equivalent of more than four per ct. of arsenious oxide in the form of water-soluble arsenic compounds. The water-soluble arsenic most commonly occurring in Paris green is in the form of arsenious oxide, commercially known as common white arsenic.

The method of analysis used by us in determining the amount of water-soluble arsenic compounds in Paris green should show the full amount of such compounds that would be found in actual field work where Paris green is mixed with water at the rate of one part by weight of Paris green to 1,000 parts of water and the mixture used soon after preparation. By longer extraction with water, larger quantities of soluble arsenic compounds can be obtained; but for our purpose, it is desirable to approximate the amount likely to be found in actual field practice in

the use of Paris green under the conditions commonly employed. It would, in our judgment, be proper to condemn for use as an insecticide Paris green or other similar materials that yield more than four per ct. of water-soluble arsenic compounds expressed as arsenious oxide when treated for 24 hours with distilled water at the rate of 1000 parts of water for one part of Paris green or arsenic-containing materials.

The water-soluble arsenious oxide varies in the 22 samples of Paris green examined from 0.51 to 15.69 per ct. and averages 1.68 per ct. Excluding sample No. 50 from the average, the amount of water-soluble arsenious oxide in the remaining 21 samples is a trifle over one per ct., very far below limit of harm prescribed for use as an insecticide. Sample No. 50 is to be condemned as wholly unfit for insecticidal purposes on account of the very large excess of arsenic compounds present in water-soluble forms.

3. *Copper in Paris green determined as copper oxide.*—The amount of copper expressed as the equivalent of copper oxide varies in the 22 samples of Paris green examined from 6.86 to 30.73 per ct. and averages 28.97 per ct. However, sample No. 50 is clearly shown by its low copper content not to be Paris green at all, or, at least, to contain only a small proportion of Paris green, and we may properly exclude this from our average. Then in the remaining cases the average is 30.02 per ct. of copper oxide, about the same as last year.

4. *Relation of copper oxide to arsenious oxide in Paris green.*—In pure copper aceto-arsenite there are 1.87 pounds of arsenious oxide for one pound of copper oxide. Now, this relation is of value in showing whether Paris green contains more arsenious oxide than it ought. The chief adulterant used in Paris green is arsenious oxide, commercially known as white arsenic. This is used because it is cheaper than Paris green and also because it can be safely added without any danger of reducing the amount of arsenious oxide. In fact, a very poor quality of Paris green can be brought up to the legal requirements by addition of arsenious oxide. However, arsenious oxide cannot be

added to Paris green without increasing the ratio of arsenious oxide to copper oxide above 1.87. In the samples examined, excluding No. 50, the ratio of arsenious oxide to copper oxide varies from 1.81 to 2.24 and averages 1.89. In sample No. 33 the arsenious oxide exceeds 60 per ct. and the copper is less than 28 per ct.; hence, the arsenious oxide is present in amounts more than twice exceeding the copper oxide. In other words, there is too much arsenious oxide for the copper oxide present and the only possible inference is that white arsenic or some other arsenic compound has either been added purposely or is present as the result of carelessness in manufacture.

5. *Results of microscopic examination.*—In Bulletin No. 126 of the California Experiment Station, the microscopic examination of Paris green for adulteration, especially that of uncombined arsenious oxide (common white arsenic) is highly recommended. This test in our hands has been found helpful as an adjunct, but cannot take the place of chemical analysis. We cannot in our work see any definite relation between the number of crystals of arsenious oxide shown by the microscope and the amount of water-soluble arsenious oxide as shown by chemical determination. So far as our experience with the samples examined goes, microscopic examination cannot be relied upon to distinguish with certainty a Paris green containing an injurious amount of water-soluble arsenic.

6. *Solubility of Paris green in ammonia.*—The solubility of Paris green in ammonia is a useful test for detecting the presence of insoluble adulterants like barium sulphate, calcium sulphate and similar materials. It cannot, however, be regarded as an entirely reliable test for detecting the presence of arsenious oxide or common white arsenic, the most common impurity of Paris green.

7. *General conclusion as to purity of Paris green in market.*—Our results indicate a satisfactory condition as to the arsenic content of Paris green found in the market during 1900, and the same can be said as to the amount of water-soluble compounds present in the samples examined, excepting only, No. 50.

EXAMINATION OF MISCELLANEOUS INSECTICIDES.

ANALYSIS OF ARSENOID.

The sample examined was made by the Adler Color and Chemical Works of New York city and contains:

Total arsenic equivalent to arsenious oxide	58.82	per ct.
Water-soluble arsenic equivalent to arsenious oxide	2.94	"
Copper equivalent to copper oxide	30.76	"
Moisture	1.91	"

ANALYSIS OF PARAGRENE.

One sample of this material was found to contain:

Total arsenic equivalent to arsenious oxide	36.11	per ct.
Water-soluble arsenic equivalent to arsenious oxide	1.47	"
Copper equivalent to copper oxide	17.87	"
Calcium equivalent to calcium oxide	14.20	"
Moisture	8.15	"

ANALYSIS OF BLACK DEATH.

Moisture	9.78	per ct.
Sulphate of lime (gypsum)	45.34	"
Magnesium oxide	3.98	"
Iron and aluminum oxide	3.02	"
Arsenious oxide	0.79	"
Copper oxide	0.41	"
Silica	5.42	"
Loss on ignition	28.91	"

Whatever efficiency this material may have as an insecticide is not due to the Paris green or other arsenic compounds contained in it.

ANALYSIS OF BUG DEATH.

Moisture	0.25	per ct.
Zinc oxide	86.80	"
Iron oxide	5.20	"
Lead oxide	2.01	"
Silica	2.96	"
Loss on ignition	2.43	"
Phosphoric acid	0.03	"
Nitrogen	0.04	"
Potash	0.00	"

Some claims are made for this material as a fertilizer, but the claims are not supported by the results of analysis.

HAMMOND'S SLUG SHOT.

Moisture	10.88	per ct.
Sulphate of lime (gypsum)	74.72	"
Arsenious oxide	1.04	"
Copper oxide	0.59	"
Iron and aluminum oxides	3.15	"
Silica	2.77	"
Loss on ignition	6.78	"

DEFECTS OF PRESENT PARIS GREEN LAW.

In its present form the Paris green law of this State is seriously defective in several respects, most prominent of which are the following:

1st. The present law wholly fails to protect consumers from adulteration of Paris green by water-soluble arsenic compounds, the most common of which is uncombined arsenious oxide or common white arsenic.

2d. The total amount of arsenic required in Paris green by the present law, viz., the equivalent of 50 per ct. of arsenious oxide is needlessly low. In our examination of Paris green as sold in this State during the past two years, the lowest amount of arsenic found was 55.34 per ct., over five per ct. above the present required standard.

3d. The law fails to require that the arsenious oxide in Paris green should be in combination with copper. This omission offers opportunity for serious abuse. Sample No. 50 offers a good illustration of this. In that case there is not one-fourth as much copper as should be present to combine with the arsenic.

In order to remedy these defects, the section of the law that so completely fails to define Paris green, should be changed so as to cover the following points:

1st. Paris green should be required to contain an amount of arsenic in combination with copper equivalent to 54 per ct. of arsenious oxide.

2d. Paris green should be legally declared adulterated if it contains arsenic in water-soluble forms equivalent to more than three per ct. of arsenious oxide.

APPENDIX.

I. Periodicals received by the Station.

II. Meteorological records.

Appendix.

PERIODICALS RECEIVED BY THE STATION.

Acker und Gartenbau Zeitung	Complimentary.
Agricultural Education	"
Agricultural Epitomist	"
Agricultural Gazette of New South Wales	"
Agricultural Student	"
Agricultural Students' Gazette	"
Albany Journal	Subscription.
Allegan Gazette	Complimentary.
American Agriculturist	Subscription.
American Chemical Journal	"
American Chemical Society, Journal	"
American Cultivator	Complimentary.
American Entomological Society, Transactions.	Subscription.
American Fancier	"
American Fertilizer	"
American Florist	"
American Gardening	"
American Grange Bulletin	Complimentary.
American Grocer	"
American Journal of Physiology	Subscription.
American Monthly Microscopical Journal	"
American Naturalist	"
American Philosophical Society, Proceedings	Complimentary.
American Stock Keeper	"
Analyst	Subscription.
Angelica Every Week	Complimentary.

Annales Agronomiques	Subscription.
Annales de l'Institut Pasteur	"
Annals and Magazine of Natural History	"
Annals of Botany	"
Archiv der gesammte Physiologie (Pflueger)	"
Archiv fuer Hygiene	"
Association Belge des Chimistes, Bulletin	Complimentary.
Baltimore Weekly Sun	"
Beet Sugar Gazette	"
Berichte der deutschen botanischen Gesellschaft	Subscription.
Berichte der deutschen chemischen Gesellschaft	"
Boletin do Instituto Agronomico do Estado de Sao Paulo	Complimentary.
Boletin de Agricultura Tropical	"
Boston Society of Natural History, Proceedings	Subscription.
Botanical Department, Jamaica, Bulletin	Complimentary.
Botanical Gazette	Subscription.
Botanische Zeitung	"
Botanisches Centralblatt	"
Botaniste, Le	"
Breeders' Gazette	"
Buffalo Society of Natural Sciences, Bulletin	Complimentary.
Canadian Entomologist	Subscription.
Canadian Horticulturist	Complimentary.
Centralblatt fuer Agrikultur-Chemie	Subscription.
Centralblatt fuer Bakteriologie und Parasitenkunde	"
Chemical News	"
Chemical Society, Journal	"
Chemiker Zeitung	"
Chemisches Centralblatt	"
Chicago Daily Drovers' Journal	Complimentary.
Chicago Dairy Produce	"
Cincinnati Society of Natural History, Journal.	"

Columbus Horticultural Society, Journal......	Complimentary.
Commercial Gazette	"
Commercial Poultry	"
Comptes Rendus	Subscription.
Country Gentleman	"
Country World	Complimentary.
Dairy and Creamery.........................	"
DeRuyter Gleaner	"
Detroit Free Press.........................	"
Edwards' Fruit-Grower and Farmer...........	"
Elgin Dairy Report.........................	"
Elisha Mitchell Scientific Society, Journal.....	"
English Catalogue of Books.................	"
Entomological News	Subscription.
Entomological Society of Washington, Proceedings	"
Entomologische Zeitschrift	"
Entomologist	"
Entomologists' Record	"
Fanciers' Review	Complimentary.
Farm and Fireside..........................	"
Farm and Home..............................	"
Farm Journal	"
Farm News	"
Farm Poultry Semi-Monthly..................	"
Farm, Stock and Home.......................	"
Farmers' Advocate	"
Farmers' Call	"
Farmers' Guide	"
Farmers' Home	"
Farmers' Magazine	"
Farmers' Tribune	"
Farmers' Voice	"
Feather	Subscription.
Feathered World	"
Florists' Exchange	"

Fuehling's landwirtschaftliche Zeitung	Subscription.
Garden	"
Gardners' Chronicle	"
Gardening	"
Geneva Gazette	Complimentary.
Gleanings in Bee Culture	"
Golden Egg	"
Green's Fruit Grower	"
Hedwigia	Subscription.
Herd Register	Complimentary.
Hoard's Dairyman	"
Holstein-Friesian Register	"
Homestead	"
Horticultural Visitor	"
Indiana Farmer	"
Industrie Laitiere	"
Irrigation Age	"
Ithaca Democrat	"
Jahresbericht der Agrikultur-Chemie	Subscription.
Jahresbericht der Nahrungs und Genussmittel.	"
Jersey Bulletin	Complimentary.
Journal d'Agriculture Pratique	Subscription.
Journal of Applied Microscopy	"
Journal de Botanique	"
Journal of Experimental Medicine	"
Journal fuer Landwirtschaft	"
Journal of Physiology	"
Just's Botanischer Jahresbericht	"
Landwirtschaftlicher Jahrbuch	"
Landwirtschaftlichen Versuchs-Stationen	"
Louisiana Planter	Complimentary.
Meehan's Monthly	Subscription.
Michigan Sugar Beet	Complimentary.
Milch Zeitung	Subscription.
Mirror and Farmer	Complimentary.
Monthly Weather Review	"

National Nurseryman	Complimentary.
National Farmer and Stock Grower	"
National Stockman and Farmer	"
Naturae Novitates	"
Naturaliste	Subscription.
Naturaliste Canadienne	"
Nature	"
Nebraska Farmer	Complimentary.
New England Farmer	"
New York Academy of Science, Annals and Transactions	Subscription.
New York Botanical Garden, Bulletin	Complimentary.
New York Entomological Society, Journal	Subscription.
New York State Granger	Complimentary.
North American Horticulturist	"
Northwest Horticulturist	"
Northwest Pacific Farmer	"
Oesterreichische Chemiker Zeitung	Subscription.
Ohio Poultry Journal	"
Oregon Agriculturist	Complimentary.
Pacific Coast Dairyman	"
Pacific Coast Fanciers' Monthly	Subscription.
Pacific Rural Press	"
Plattsburgh News	Complimentary.
Pomona Herald	"
Popular Agriculturist	"
Poultry Herald	Subscription.
Poultry Keeper	Complimentary.
Poultry Industry	"
Poultry Monthly	"
Poultry Star	"
Practical Farmer	"
Practical Fruit-Grower	"
Prairie Farmer	"
Progres Agricole et Viticole	Subscription.
Psyche	"

Public Ledger, Philadelphia	Complimentary.
Queensland Agricultural Journal	"
Revue Generale de Botanique	Subscription.
Revue Horticole	"
Revue Mycologique	"
Royal Agricultural Society, Journal	"
Rural New Yorker	"
Salt Lake Herald	Complimentary
Saint Louis Academy of Science, Transactions.	"
Sanitary Inspector	"
Science	Subscription.
Society of Chemical Industry Journal	"
Societe Entomologique de France, Bulletin	Complimentary.
Societe Mycologique de France, Bulletin	Subscription.
Southern Planter	Complimentary.
Southern Farm Magazine	"
Southwestern Farmer and American Horticulturist	"
Stazione Sperimentale Agrarie Italiane	"
Strawberry Specialist	"
Suffolk Bulletin	"
Sugar Beet	"
Texas Stockman and Farmer	"
Torrey Botanical Club, Bulletins and Memoirs.	Subscription.
Up-to-Date Farming and Gardening	Complimentary.
Utica Semi-Weekly Press	"
Wallace's Farmer	"
Watkins Review	"
West Virginia Farm Reporter	"
Western Fruit-Grower	"
Western Plowman	"
Wiener illustrierte Garten-Zeitung	Subscription.
Woman's Home Companion	Complimentary.
Zeitschrift fuer analytische Chemie	Subscription.
Zeitschrift fuer Biologie	"
Zeitschrift fuer Entomologie	Complimentary.

Zeitschrift fuer Fleisch und Milch Hygiene....	Subscription.
Zeitschrift fuer Pflanzenkrankheiten	"
Zeitschrift fuer physiologische Chemie........	"
Zeitschrift fuer Untersuchung der Nahrungs und Genuss-Mittel	"
Zoologischer Anzeiger	"
Zoological Record	"

METEOROLOGICAL RECORD FOR 1900.

READING OF MAXIMUM AND MINIMUM THERMOMETERS AT 7 A. M.

DATE.	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Mix.	Max.	Min.
1	12	2	11	4	28	15	38	28	77	43	86	60	70	50	86	61	86	61	67	44	55	50	43	33
2	25	7	12.5	3	28.5	19	50	34	56	34	77	64	72	53	74	51	88	65	73	45	63.5	47	39.5	35
3	25	12	16	2.5	25	12	55	35	77	46	84	53	80	57	78	57	92	70	80	60	60	38	44	30
4	23	10	27	8	33	12	47	29	54	33	62	49	90	65	75	52	94	61	83	58	58	36	55	33
5	33	22	39.5	17	40	3	38	28	52	33	77	52	84	65	75	54	82	53	83	60	63	36	42	33
6	40	31	26	12	33	3	52.5	32	52	33	83	55.5	90	66	89	62	87	60	89	62	54	37	36	32
7	36	24	37	18	42	23	57	37	53	27	86	62	93	69	97	71	86.5	61	89	63	52	37	36	32
8	44	30	44	28	29	10	56	34.4	60	40	85	61	92	72	95.5	76	73	48	80	53	48	37	41	27
9	30	10	53	33	35	10	44	22	82	41	83	54	83	62	95.5	72	82	55.5	58	45	51	33	40	23
10	45	14	35	23	46	21	34	24	45	32	70	45	67	59.5	94	74	85.5	56	55	40	38	30	32	4
11	42	10	34	23	35	9	34	25	50	33	81	56	79	61	97	77	87	58	55	41	41	32	25	6
12	35	11	44	25	20	—3	50	32	57	39	80	50	91	61	96	60	95	64	66	44	49	31	28	15
13	29	21	47.5	34	24	0	50	32	68	39	74	47	77	59	74	60	76	53	74	45	42	32	40	15
14	34	26	57.0	19	38	21	44	31	83	60	82	56	81	62	76	60	79	56	69	46	46	25	41	4
15	36	30	29.5	19	23	5	47	34	88.5	69	77	49.5	84.5	65	80	60	77	42	61	47	33	24	12	5
16	39	30	36	8	22	8	60.5	38	88.5	48	77	49.5	91	69	87	65	82	49	73	47	31	24	15	5
17	34	25	19.5	8	22	4	66	39	67	50	82	52.5	96	72	83.5	66	82	51	66.5	33	34	19	18	10
18	38	25	22	11	13	0	60	44	83	49	81	51	95	73	83	63	63.5	47	52.5	33.5	43	29	30	10
19	41	36	20	9	35	5	*	*	55	45	75	51	76	56	86	62	65	37	60	39	64	40	40	25
20	54	36	18	9	45	28	......	......	59	42	79.5	55	83	64	75	61	70	38	48	28	61	39	39	29
21	49	17	28	8	37	19	......	......	66	45	83.5	53.5	87	70	70	60	63	55	60	31	63	54	38	28
22	36	15	42	25	29	18	......	......	63.5	40	86	60	77	54	69	57	72	50	70	43	70	34	32	23
23	56	33	45	28	45	21	......	......	74	52	75	57	84	58	83	56	69.5	49	76.5	48	60	35	48	26
24	44	9	34	26	41	21	......	......	80	54	81	53	87	61	87	64	68	47	69	53	48	33	47	35
25	39	9	44	3	30	15	59	36	75	51	93	66	88	66	89	67	75	49	68	50	40	32	47	31
26	40	9	12	3	36	15	58.5	39	76	49	87	56	72	59	97	70	82	54	68	52	35	31	38	25
27	15	4	5	0	37	21	61	38	77	44	91	68	78	56	91	68	93	65	73	54	37	31	27	18
28	26	14	19	2	42	23	64	43	82	56	90	67	77	52	90	64	73	48	61	51	33	25	30	23
29	39	3	......	......	36	24	65	40	73	52	90	60	82.5	59	86	65	70	40	66	52	40	30	34	18
30	15	3	......	......	39	25	73.5	47	75	54	83	48	89	65	89	59	68	58	67	53	42	29.5	36	18
31	23	5	......	......	40	26	......	......	74	58	......	.....	82.5	62	87	61	......	......	58	52	......	......	35	18
Average........	34.9	17.2	30.6	14.6	33.2	14.0	52.7	34.2	68.5	44.9	81.4	55.4	83.2	62	85	63.1	78.9	53.3	68.4	47.4	48.5	33.7	35.8	21.7

*Thermometers broken. Month average is 24 days.

AVERAGE MONTHLY TEMPERATURE SINCE 1882.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5
1895	21.8	16.9	26.9	44.4	59.0	....	....	71.2	61.7	45.4	39.6	31.4
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2
1898	26.2	26.8	....	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7

PRECIPITATION BY MONTHS SINCE 1882.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	....	....	....	....	....	3.69	2.42	2.37	1.25	0.62	1.22	0.55	....
1883	0.48	1.44	0.68	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99+	4.02	2.73	3.47	2.02	1.24+	27.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.63	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	5.81	4.54	2.40	....	36.83
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	0.00	0.29	1.33	2.88	....	....	2.66	0.94	0.72	2.31	2.49	....
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.52	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73

WIND RECORD FOR 1900.

DATE.	January.				February.				March.				April.			
	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1			4	18				24	5	5		8			1	23
2			5	16				18				24	3		3	10
3			6	16				16				23	9		2	5
4		12		7	2	2	7	1	8			15				20
5		9	5	5				19	13							24
6				10	2		7	3		3	15	6	8			16
7		6	4	1			12	2				24	4			18
8	1			20			24				8	5	5			19
9		3	11				5	19			16		10			14
10			5	17				9	4			19	6			9
11		6	12		0	0	0	0	19			4	1	10		2
12				18			22		4			6		5	14	3
13				8			11	12			17	6				13
14			7	7				19				24				20
15	0	0	0	0				15				11	1			18
16		2	3	16				20	4			15		10	2	
17	2	9		2	3			15			1	20			24	
18		4	20					24		3	16	4			24	
19		1	6					24		6	17	1			1	22
20	6		3	2				11				24	1	1		1
21	12		2	6		6	10					14		6	7	
22			9	3		14	8				9	9		8	1	
23	3		6	13			2	22	2			18	5			6
24	5	4	12				7	6	2			19	8			11
25	1		12	2				21		1		6	5			10
26				24				24		6	4	4	3			21
27				11	4		2	8				24	4			17
28			16	6		6	18					24	5			15
29				21					4			15	2		2	8
30			2	13					15						7	12
31	2			22					5			18				
Total hours of movement	32	56	150	287	11	28	135	335	85	24	103	400	80	40	88	337
Percentage of time in each direction	6.0	10.7	28.6	54.7	2.2	5.5	26.5	05.8	13.9	3.9	16.8	65.4	14.7	7.3	16.2	61.8

WIND RECORD FOR 1900—(*Continued*).

DATE.	May.				June.				July.				August.			
	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Eas'erly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1	......	......	......	20	3	......	1	5	......	......	......	21	13	......	......	7
2	......	......	10	3	......	......	7	17	3	......	......	4	......	......	3	17
3	......	......	......	20	......	......	......	23	......	......	7	10	10	......	......	5
4	......	......	......	22	2	5	2	1	5	......	......	6	5	......	......	3
5	......	......	......	23	3	......	1	5	0	0	0	0	......	......	3	3
6	1	......	4	11	......	2	13	......	......	......	......	15	......	......	......	19
7	1	8	2	......	......	......	21	1	......	......	3	15	......	......	......	17
8	......	2	9	10	6	......	......	8	......	......	......	19	......	......	......	24
9	......	......	......	20	9	......	......	10	......	......	......	23	3	......	......	16
10	8	......	......	13	......	12	5	......	......	......	......	17	......	......	......	23
11	......	......	4	7	3	2	8	11	......	3	6	8	......	......	......	21
12	......	6	......	2	3	4	......	8	2	......	......	19	14	......	......	......
13	......	......	......	15	......	......	18	......	......	......	......	22	......	......	......	13
14	......	......	......	24	6	......	7	7	......	......	......	17	1	......	......	7
15	6	......	......	17	14	......	......	5	2	......	......	13	2	......	......	1
16	5	......	......	......	4	......	......	3	......	......	......	11	......	......	......	9
17	4	2	10	3	14	......	......	2	......	......	2	15	7	......	......	8
18	7	......	......	......	15	......	......	4	......	......	......	12	1	......	......	10
19	21	......	......	......	10	......	......	5	......	4	......	4	11	......	......	3
20	5	......	......	15	3	......	......	19	2	......	......	......	......	6	4	......
21	2	......	......	20	3	......	......	11	......	......	......	13	......	21	1	......
22	......	......	......	21	3	......	......	......	......	......	......	1	6	1	1	......
23	......	......	4	4	9	2	......	2	0	0	0	0	......	4	5	4
24	......	3	6	......	3	......	1	8	......	......	2	......	......	......	10	7
25	......	9	5	......	6	......	......	10	2	......	1	10	......	5	2	2
26	......	5	8	......	......	......	6	11	7	......	......	11	1	3	3	......
27	1	5	1	2	......	......	......	20	4	......	......	10	......	......	9	3
28	......	6	......	2	6	......	1	16	......	......	4	2	......	......	9	......
29	......	16	7	......	1	......	......	23	......	......	11	3	2	......	......	11
30	......	6	15	......	......	......	......	24	3	......	......	5	4	......	......	13
31	6	......	1	15	......	......	......	......	......	......	......	22	5	......	......	9
Total hours of movement	67	68	86	290	126	27	91	259	30	7	36	328	85	40	50	255
Percentage of time in each direction	13.1	13.3	16.8	56.8	25.0	5.4	18.1	51.5	7.5	1.7	9.0	81.8	19.8	9.3	11.6	59.3

WIND RECORD FOR 1900—(*Concluded*).

DATE.	September. Northerly, N. W. to N. E.	September. Easterly, N. E. to S. E.	September. Southerly, S. E. to S. W.	September. Westerly, S. W. to N. W.	October. Northerly, N. W. to N. E.	October. Easterly, N. E. to S. E.	October. Southerly, S. E. to S. W.	October. Westerly, S. W. to N. W.	November. Northerly, N. W. to N. E.	November. Easterly, N. E. to S. E.	November. Southerly, S. E. to S. W.	November. Westerly, S. W. to N. W.	December. Northerly, N. W. to N. E.	December. Easterly, N. E. to S. E.	December. Southerly, S. E. to S. W.	December. Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1	....	6	4	3	....	....	....	....	....	....	21	2	....	....	....	8
2	....	6	11	....	....	8	1	....	....	....	....	18	....	....	....	10
3	....	....	11	8	....	6	13	....	....	....	....	6	....	....	6	....
4	3	....	....	8	....	3	17	....	....	3	9	....	1	3	3	2
5	....	....	2	9	....	....	9	6	4	....	1	12	....	....	....	24
6	1	....	....	14	2	....	....	....	....	....	....	18	....	....	....	17
7	11	....	....	....	....	....	22	....	....	....	6	5	2	....	5	....
8	3	....	3	2	2	....	....	15	3	....	....	8	1	....	4	2
9	4	....	....	5	7	....	....	5	....	....	....	24	....	....	2	22
10	1	....	....	....	10	....	....	7	....	....	....	18	....	....	6	15
11	....	....	1	6	....	....	....	24	....	....	....	9	2	....	....	16
12	3	....	6	12	....	....	....	6	....	....	....	17	....	....	12	11
13	1	....	....	12	....	....	4	3	....	....	8	11	....	....	4	20
14	2	....	....	14	8	....	2	5	1	....	....	15	....	....	....	21
15	....	5	12	....	....	....	....	18	....	....	....	17	....	....	....	....
16	....	....	8	15	....	....	4	16	6	....	....	10	....	....	....	18
17	....	....	....	24	1	....	....	18	....	....	16	3	....	10	5	....
18	6	....	....	12	2	....	....	22	1	....	12	5	....	....	22	2
19	....	7	4	4	12	....	....	6	8	1	8	....	....	....	....	17
20	....	....	22	....	....	5	10	....	3	....	13	....	....	....	....	23
21	1	....	3	15	....	4	14	....	....	....	10	12	5	....	....	....
22	....	....	....	23	....	13	7	....	....	7	5	7	....	5	13	....
23	3	....	....	11	....	10	7	....	....	....	3	14	....	....	24	....
24	4	....	....	7	2	....	....	9	3	9	....	2	1	....	3	15
25	....	2	3	....	....	....	3	....	5	6	....	....	....	....	8	11
26	....	2	1	10	....	1	18	....	7	....	....	2	....	....	....	23
27	....	....	....	23	1	....	3	12	....	....	....	19	....	....	3	7
28	2	....	....	11	....	....	3	3	....	6	8	....	....	3	4	6
29	....	....	8	....	....	3	4	....	....	....	8	6	....	....	2	11
30	2	....	3	....	5	3	....	1	....	....	....	17	....	....	19	....
31	....	....	....	....	....	9	15	....	....	....	....	....	2	....	1	6
Total hours of movement	55	23	102	248	52	65	156	176	41	32	128	277	14	21	146	307
Percentage of time in each direction	12.7	6.4	23.6	57.3	11.6	14.5	34.7	39.2	8.6	6.7	26.8	57.9	2.9	4.3	29.9	62.9

SUMMARY OF DIRECTION OF WIND FOR 1900.

	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Total.
	Hours.	Hours.	Hours.	Hours.	Hours.
January	32	56	150	287	525
February	11	28	135	335	509
March	85	24	103	400	612
April	80	40	88	337	545
May	67	68	86	290	511
June	126	27	91	259	503
July	30	7	36	328	401
August	85	40	50	255	430
September	55	28	102	248	433
October	52	65	156	176	449
November	41	32	128	277	478
December	14	21	146	307	488
Total hours of movement	678	436	1,271	3,499	5,884
Percentage of time in each direction	11.5	7.4	21.6	59.5	....

Readings of the Standard Air Thermometer.

1900.	January.			February.			March.			April.			May.			June.		
	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.
1	9.5	15	13	5	9	8.5	26	23.5	22	35	46	44	46	53.5	55	67	76	67
2	25	22	21	4	13	12	19	23	22	36	51	46	47	72	68	68	78.5	78
3	13	19	12	11	21	22	18	25	27	36	43	38	53	44	44	54	53	57
4	23	28	27	27	39	37	33	38	20.5	30	32	36	39	50	38	60	70	73
5	34	39	39	19	22	20	4	13	12.5	33	46	49	36	43	50	64.5	78	78
6	32	35	31	26	36	32	33	37	40	44.5	53	51.5	40	52	52	65	83	82.5
7	33	40.5	41	29	40	39	24	26	25	39	54	52	43	50.5	59	66	74	77
8	30	25	20	40	46	50	10	30	31	39	42	39	52	70	74	68	80	77
9	15	28	31	34	31	28	22	40	42	25	29	32	41	40	44	58	62	69
10	42	36	25	24	30	30	34	32	26	26	30	30	38	45	48	58	72	79
11	11	24	26	25.5	39	41	10	17.5	10	33	42	48	41	57	50	71	77	76.5
12	25	24	23	35	39	37	0	16	19	39	42	46	47	60	67	57	70.5	71
13	28	32	31	47	57	34	23.5	33	36.5	33	37	40	61	78	80	56	75.5	76
14	31	32	36	20	27	26	22	21	15	35	46	44.5	72	87	84	67	75	72
15	31	34	34	22	35.5	23	9	20	13	44	56	51	75	87	68	61	73	73
16	34	34	34	8	19.5	18	13	19	20	40	60	59	51.5	64	63.5	66	79.5	74
17	26	29	34	12	21	18	5	10.5	10	45	53	55	65	77	72	64	77	73
18	38	40	40	14	18	16	6	16	27	59	70	67	51	54	50	60	71	71
19	40	50	46	11	15	17	34	44.5	40	55	57	59	45	51	57	64	74.5	75
20	41	45	38.5	9	26.5	25	29	35	30	48	61	65	55	63	54	69	82	80
21	19	23	29	26	38	39	20.5	27	25	49.5	71	65	53	56.5	61	71	83	80
22	35	52	46	36	44	40.5	22	38.5	40	52.5	63	63	56	69	72	65	74	70
23	43	41	33	29	32	31	35	40	35	56	58	59	61	73	71	61	78	76.5
24	10	23	36	33	40	43	23	27	27	47	57	54	57	70	71	72	89	85
25	39	39	36	4	10.5	8	20	32	30.5	45	56	56	60	74	73	73.5	84	82
26	10	7	7	3	4	1.5	22	33	34	46	55	60	57	73	75	69	88	78
27	15	22	21	2	15	15.5	32	99	37	45	53	61	57	79	71	78	85	88
28	25	34	36.5	16.5	20.5	27	25.5	34	36	50	61	62	62	73	68	71	89	76
29	5	12	12	....	....	....	31	37	36	52	70	66.5	57	68	73	70	81	74
30	13	22	27	....	....	....	28	38	33	55	73	56	59	65	72	55	67	64
31	6	10	6	....	....	....	30	35	37	....	....	....	73	83	81	....	....	....
Average	25.2	29.6	28.8	20.4	23.2	26.4	21.4	29.1	27.7	42.4	52.2	51.8	53.2	63.9	63.4	65	76.7	75.1

READINGS OF THE STANDARD AIR THEMOMETER—(*Concluded*).

1900.	July.			August.			September.			October.			November.			December.		
	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.	7 a. m.	12 m.	6 p. m.
1	56.5	70	69.5	63	69.5	72	66	84	83	46.5	68	69	53	60	59	36	39	39
2	57	75	75	61	76	77	72	86	78	60	76.5	76	48.5	56	50	37	43	40
3	70	89	86	62	71.5	70	75	92	72	63	77.5	75.5	41	50.5	49	32	51	47
4	77	79	81	61	75	71	67	78	71.5	61	76	78	36.5	56.5	56.5	40	40	35
5	71	84.5	87	63.5	84	88	62	81	80	66	85	84	50	50	4	33	34	35
6	70	89	88	79	93	94	75	82	78	65	87	84	38	49	45	34	84	31
7	82	91	88	81	93.5	77	62	68	67	70	77	73	42	45	45	32	36	36
8	75	73	73	81	91	82.5	57	75	73	54	55	54	37	49	40	27	30	32
9	64	63	64	76	91	91	65	92.5	77	47	51.5	49	34	33	36	30	23	17
10	62	74	75	79	94	94	59	80	76	43.5	52	51	33	37	36	6	23	21
11	66	82.5	71	83	91.5	91	68	92	83	47	61	62	34	45	41	18	24	21
12	62	73	72.5	61	66.5	67	76	71	66	47	65	66	32	40	41	17	26	26
13	63	77	79	63	75	68	58.5	71	73	47	60	63	34	40	43	40	32	26
14	70	82	81	61	67	76	64	74	69	55	57	59	27	31	26	5	9	11
15	70.5	84	82	65	79	78	50	73	75	49	69	65	24	28.5	25	8	10	10
16	77	93	92	67	77	81	65	81	63	53	55	42.5	24	31	26	14	17.5	14
17	81.5	89	91	70	81.5	78	53	57	56	34	46	47.5	30	32	34	12	21	21
18	74	70	75	67.5	85	82	51	64	61	47	56.5	56	43	52.5	59	30	36	36
19	68	79	79.5	66	74	66	39	63	65	36.5	42	39	41	44	53	37	36	37
20	72	83	82	62	63	69	55	59	61	32	53	55	54	61	62	36	37	35
21	76	74	76	65	67	66.5	61.5	71	64	43	63	64	60	58	43	28	29	29
22	69	77	80	61	78	78	55	65	64	49	69	67	36.5	44	45	27	42	39
23	70	83.5	80	64	81	81	52	65	61	63	68	62	45	42	39	35	45	45
24	71.5	84	83	72	87	84	54	72	65	57	61	62	34	40	36	39	44	38
25	67	68	72	73	90	92	54	76	76	53	64	63	33	33	33	33	33	32
26	63	75	75	78	82.5	82.5	67	87	84	55	69	64	34	37	34	27	25	22
27	63	74	71	74	89	75	69	77	66	57	59	58	32	32	32	23	28	28
28	64	77	81	68	82	80	53	66	57	52	63	62	27	38	33	30	33.5	27
29	68	84.5	85.5	73	86	81	61	66	65	53	64	61	39	41	35	26	30	27
30	67	81	78	67	84	78	59	61	61	56	56	58	34	39	36.5	19	31	33.5
31	68.5	82	81	68.5	83.5	79	....	....	... .	53	53.5	52	....	....	....	32	34	34
Average	68.9	79.4	79.2	68.9	80.9	79	60.8	74	69.8	52.1	63.2	62	37.7	43.2	41.3	27.2	31.5	29.9

SUMMARY OF MAXIMUM, MINIMUM AND STANDARD THERMOMETERS.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Maximum	34.9	30.6	33.2	*52.7	68.5	81.4	83.2	85	78.9	68.4	48.5	35.8
Minimum	17.2	14.6	14.0	*34.2	44.9	55.4	62.0	63.1	53.3	47.4	33.7	21.7
Standard, 7 a. m.	25.2	20.4	21.4	42.4	53.2	65.0	68.9	68.9	60.8	52.1	37.7	27.2
Standard, 12 m.	29.6	28.2	29.1	52.2	63.9	76.7	79.4	80.9	74.0	63.2	43.2	31.5
Standard, 6 p. m.	28.8	26.4	27.7	51.8	63.5	75.1	79.2	79	69.8	62	41.3	29.9

* Average of 24 days.

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